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The Engineer

VOL. CXCIV—JULY TO DECEMBER, 1952

London:
28, ESSEX STREET, STRAND, W.C.2

SO 3427

JULY 4, 1952

THE ENGINEER

A Seven-Day Journal

Cross-Channel Air Ferrying

AN independent British airline to-day announced certain details of its ten-year development programme, in which it hopes to employ an unusual form of helicopter when its present fleet of freight aeroplanes begins to wear out. Air Commodore Powell, managing director of Silver City Airways, operators of the cross-Channel car and cycle ferries, announced that the company was interested in operating a fleet of large helicopters with completely detachable fuselages and that, in consequence, a specification had been issued to a number of firms in the British aircraft industry. Each helicopter unit will consist of an upper component, or "prime mover," and three or four load-containing panniers which can be picked up and clipped to the "prime mover" at will. The "prime mover" will incorporate the engines, rotors, fuel tanks and crew accommodation. The detachable pannier will be a long, streamlined box, capable of carrying two cars, a number of cycles and motor-cycles and twelve passengers, who will sit in a specially designed observation saloon at the front end of the pannier. The currently used Bristol "Freighter" spends twenty minutes on the ground between flights to discharge and embark cargoes of cars and passengers. This is a very rapid rate of turn-round, but since the cross-Channel flight also takes only twenty minutes, the number of hours of work which each aeroplane can perform in a day's car ferry operation is comparatively small. The helicopter's work-hours potential will be substantially greater for it will be able to fly continuously day and night until landing to refuel or to change the operating crew. As the helicopter lends itself to varied development so far as the shape of the fuselage is concerned, it has been assumed that the machine adopted will be a major variation of the normal passenger helicopter developed for one of the airline Corporations or for the armed forces. In 1951 the company operated six Bristol "Freighter" aircraft, each capable of carrying two cars and up to twelve passengers, together with a number of motor-cycles and bicycles. The present fleet is nine "Freighter" aircraft, and an order was recently placed for six more "Freighters" of an improved design, costing £90,000 each. They have longer noses and the length of the freight hold will be extended to give a maximum length of 37ft. As a result, these new aircraft will be able to carry a maximum of three cars and twenty passengers. The company hopes to obtain higher frequency operation of the existing cross-Channel routes and possibly some other short freight routes, including a direct London-Paris air ferry using four-engined aircraft.

Water Supply in North Devon

ON Saturday, June 28th, the Prewley waterworks and treatment plant of the North Devon Water Board were officially opened by H.R.H. the Princess Royal. It may be recalled that the problems facing the Board were discussed in a paper reproduced in THE ENGINEER of December 14th, in which a general outline of the programme of new works was given. The source of supply of the Prewley works is the West Okement River, the point of intake from the river being about 1 mile from the treatment works and formed by a weir which creates a small pool at a level of 1123·25ft above sea level. Water is taken through screens from this pool into a pipe-line consisting, initially of two 12in pipes, but thereafter of one 12in pipe, which is carried through the intervening ridge by a tunnel ¼ mile long. The Board must allow 0·4 m.g.d. to flow down the stream, and the treatment plant is designed to deal with 1·4 m.g.d. The water as taken from the river, especially at higher flows, is discoloured by contact with peat and is also rather acid and therefore corrosive. Further, it contains at times some vegetable matter and bacteriologically it would not conform to the standard now expected of a public supply. The treatment at Prewley is therefore directed to (*a*) removal of colour and clarification, (*b*) removal of acidity and consequent liability to corrosion, (*c*) sterilisation. The chemical house is built over the sedimentation tank, known as an "Accelator," which embodies the principles of the suspended solids contact tank whereby sludge previously abstracted from the raw water is intimately mixed with the incoming water and the chemical reagents, thus aiding and accelerating the clarification process. The "Accelator" for these works is 37ft diameter by 16ft water depth, constructed wholly in reinforced concrete. Within the tank are built two concentric cylinders of concrete, the inner having a flared base extending well beyond the diameter of the outer. Within the inner cylinder is an electrically driven impeller provided with mixing paddles below the impeller vanes, and at this point the chemical reagents—sulphate of alumina and lime—both measured by the dry feeders, are added, together with the raw water. The water is finally withdrawn in a clarified state from a peripheral channel at the top of the tank. There are four rapid gravity filters constructed in reinforced concrete, each 20ft by 12ft 6in, having a designed capacity of 15,000 gallons per hour. After filtration, the water passes to an underground contact tank for chlorination. The water is dechlorinated—that is, the remaining chlorine is reduced to any desired proportion on leaving this tank and before it goes into the service reservoir. Chlorine is applied at present before filtration, but it can be applied after filtration if for any reason that should prove preferable. In addition, a further dose of lime is added to raise the pH value of the filtered water to a sufficient value to render the water non-corrosive and harmless to the distribution system. The service reservoir is constructed of reinforced concrete in two compartments, completely covered, and when full contains 1,500,000 gallons, the top water level being 1060ft above sea level. From the service reservoir the water goes into supply through a 15in main. The consulting engineers are Messrs. Rofe and Raffety.

The Institution of Metallurgists

THE annual general meeting of the Institution of Metallurgists was held in London on Thursday, June 26th, when Professor Hugh O'Neill, D.Sc., was installed as president, in succession to Dr. C. J. Smithells, M.C. In the opening remarks of his presidential address the president said that Dr. Smithells had not only put the finances in order but had saved the Institution from looking for a new home. Professor O'Neill mentioned that he was not directly engaged in the metallurgical industries and was more concerned with the Memorandum of Association, which referred to education and training and the maintenance of a high standard of professional conduct. The Institution, he said, resembled the early craft guilds in its three grades of membership and its objects and went on to discuss the attitude of guilds to education, which extended beyond just teaching a trade. Dissatisfaction had been expressed with present university teaching and the professor said he believed that history and the philosophy of science plus other ingredients are essential in the training of a scientist, if his education is to have breadth and not be limited only to technical training. He supported the view of John Henry Newman, who predicted that the utilitarian university would fall short of the mark. The implanting of a wider culture implies a reduction in specialisation and the president was thankful for the independence of British universities where the teaching body is free to form academic policy. The Professor referred to the requirements of a science teacher, contained in a recent report, which emphasises the need for the inclusion of the humanities in technical courses. The danger of qualifying adjectives being misunderstood in different English-speaking countries was touched upon and the president went on to consider professional conduct and mutual assistance. He suggested the formation of a benevolent fund and mentioned the publication of a "Canon of Ethics for Engineers" in the U.S.A. and felt that any code of professional conduct "would be governed by natural religion."

Laboratories at King's College, London

ON Friday last, June 27th, new physics and engineering laboratories at King's College, London, were opened by Lord Cherwell. During the war a large hole was formed in the college quadrangle by enemy bombing, thus putting an end to the use of the vaults for research, which had been carried on there for about a century. However, an opportunity was provided to build modern laboratory accommodation and excavation was started in 1949 on a two-storey building, standing below the level of the quadrangle, which has now been opened. The new physics laboratories are devoted entirely to research and cater for theoretical physics, groups working on nuclear radiation and the solid state, infra-red and ultra-violet spectroscopy and electronics; the requirements of biophysics research have been brought within the bounds of one department, with laboratory facilities in physics, physical biochemistry and biology, and it is believed that the physics department is unique in providing such an approach to fundamental problems of structures in cells and biological systems. The engineering laboratories have not yet been completely equipped, but the accommodation includes a drawing office, a soil mechanics laboratory, a concrete laboratory, a machines and structures laboratory, and electrical engineering laboratories. Much of this accommodation will be used for undergraduate instruction, and it has now become possible for the college to deal adequately with soil mechanics and concrete technology in civil engineering, with the study of vibrations in mechanical engineering, and with developments in electronics in the field of automatic control in electrical engineering. The rearrangement of space in the faculty and the provision of small rooms has helped individual and experimental work, and includes an engineering library. Although the new engineering accommodation is largely devoted to undergraduate work, the list of research at present in progress includes many problems in civil, mechanical, electrical and chemical engineering.

Harvesting of Brown Sub-Littoral Seaweeds

No. III—USE OF RECIPROCATING CUTTERS*

By PHILIP JACKSON, M.Sc., M.I.Mech.E. M.I.Chem.E., F.R.S.E., and ROBERT FAULDS McIVER, B.Sc., A.M.I.Mech.E.

Machinery is being devised for the commercial harvesting of British sub-littoral seaweeds. Two main principles are being investigated, namely, tearing the weed from the sea bed and raising it to the surface mechanically and cutting the weed from the sea bed and raising it by entrainment in water. An investigation to assess the possibility of using suitably protected standard agricultural reciprocating cutters in a seaweed harvester operating on the cutting and entrainment principle is described.

Introduction

IN the first investigations of the cutting and entrainment principle of harvesting sublittoral seaweed, described by Mackenzie[1], continuity of operation of the prototype unit was seriously interrupted by weed draping and "blinding" or jamming the cutters. A review of the results of this work by Jackson[2] attributes these troubles in part to the kind of cutter used and indicates the need for further investigation of the problems involved in the cutting operation. Briefly, these problems include (i) determination of the most effective and economic means of cutting plants from the sea bed continuously; (ii) protection of the cutters against damage by rocks; (iii) prevention of seaweed draping and consequent "blinding" or jamming of the cutter mechanism; and (iv) the design of the most suitable supporting structure for operation under the very severe conditions on the sea bed.

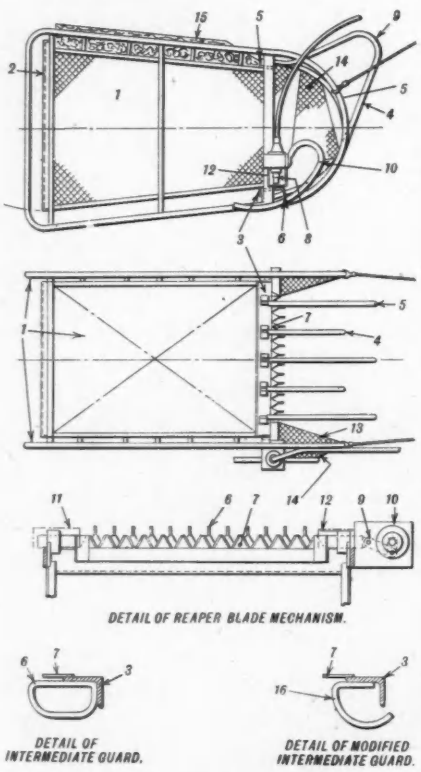


FIG. 1—ORIGINAL EXPERIMENTAL TRAWL

This report describes the investigation of some of these problems using an agricultural reaper cutter mounted in a specially designed experimental trawl for operation on the sea bed.

Experimental Equipment

The experimental trawl,† shown in Fig. 1, consisted essentially of a simple reinforced steel mesh cage (1) tapered towards the front end to counteract the tendency to plane upwards due to water pressure at speed, and fitted with a trap door (2) at the rear end to facilitate discharge of the weed after an experimental run.

Two main crossbars (3) carried, in the early experiments, five large tubular guards (4 and 5), and thirteen small intermediates (6) to protect the cutting blades against damage by rocks, but subsequent investigation of the problems of protection against damage and prevention of draping led to considerable modification of this arrangement as development proceeded. Two additional guards, which also served as skids on which the equipment was dragged along the sea bed, were formed by the outer frames of the trawl.

The cutters, consisting of two standard agricultural blades (7), were fitted to the lower leading edge and actuated by a crank mechanism (8) with a 3in-throw, driven through 64ft of $\frac{5}{8}$in dia. flexible shafting (9) from a 10 h.p. Petters diesel engine mounted on the deck of the surface vessel. By this means it was possible to operate at a maximum depth of about four fathoms. The flexible shafting was connected to the driving engine through an emergency slipping coupling set to permit a maximum power transmission to the cutters of 5 h.p. at 1000 r.p.m. A single tubular guard (10) was provided to protect the crank mechanism against damage by rocks, which passed between the main guards, and access of weed, which might cause jamming, was prevented by sheet metal covers (11 and 12).

Rope nets (13 and 14) were fitted to prevent build up of weed at the ends of the cutter bar and draping between guard (11) and the outer skid respectively.

The pressure on the sea bed was reduced, in the first experiments, by a cork float (15) on the top frame of the trawl, but, in order more successfully to negotiate obstacles, this was replaced in later experiments by a buoyancy drum secured to the leading end of the trawl.

The Institute's motorship "Asco," powered by two 100 h.p. engines, was used in these investigations, although at no time was anything approaching full power required for towing purposes and it is estimated that a 30 h.p. propulsion engine would be adequate for this duty; in fact a trawl of approximately similar size and type has actually been dragged along the sea bed by a 30 h.p. boat in experiments to test the possibility of using fixed cutters[3].

Handling of the trawl between the boat and sea bed was effected by means of a swinging derrick and power winch installed aft of the wheel house and belt driven from one of the propulsion engines.

The complete experimental set-up is shown in Fig. 2.

Experimental Procedure

The first series of experiments were primarily aimed at overcoming mechanical faults in the equipment and investigating the problems of cutter protection and prevention of draping. In each test run the trawl was dragged along the sea bed for a distance of about 100 yards, at a speed of

FIG. 2—EXPERIMENTAL SET-UP FOR TESTING THE OPERATION OF SEAWEED CUTTERS

* The previous articles were as follows: No. I—"Assessment of the Problem and Review of Preliminary Experiments," May 30th, pages 718–720, and June 6th, pages 750–751; No. II—"The Continuous Grapnel Method," June 20th, pages 814–817, June 27th, pages 846–851.

† Patent applications have been submitted to cover the equipments described in this article.

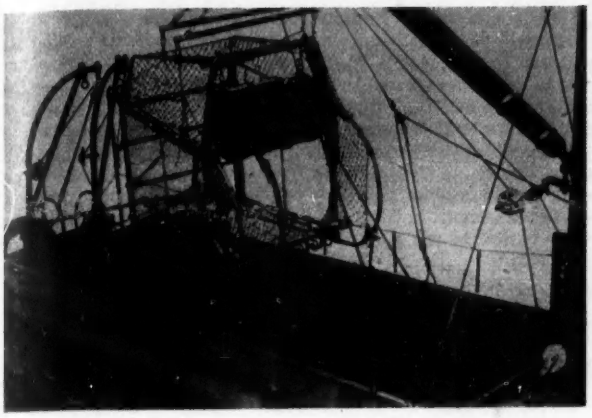


FIG. 3—FINAL ARRANGEMENT OF CUTTER GUARDS

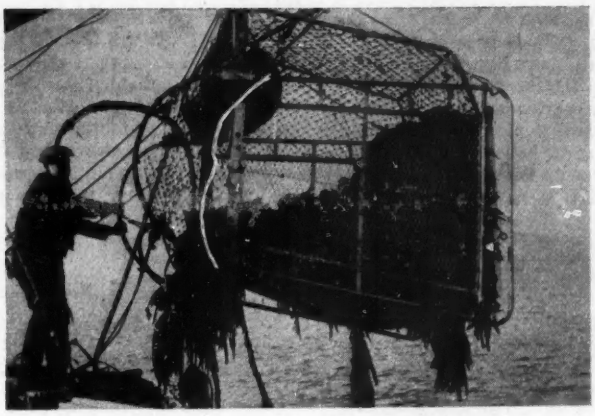


FIG. 4—EXPERIMENTAL TRAWL AFTER ONE MINUTE DRAG

about 3ft per second, with the cutters operating at a frequency of 1000 cycles per minute, after which it was raised to the surface and examined for evidence of mechanical failure, damage, or jamming, and the quantity and disposition of weed carefully noted.

Any necessary repairs and modifications were then carried out and the test procedure repeated until the equipment was proved reliable and generally satisfactory for continuous experimental operation.

In the later series of experiments the procedure was roughly similar except that the boat speed and cutter blade frequency were varied, and modifications made to the protective and anti-draping arrangements,

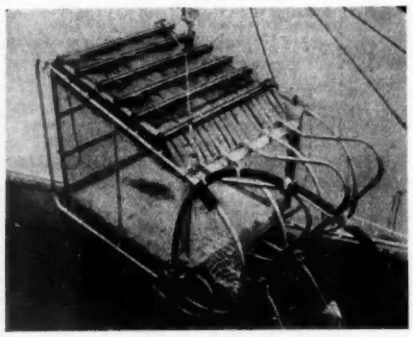


FIG. 5—ORIGINAL ARRANGEMENT OF CUTTER GUARDS

between each series. Care was taken in raising the trawl from the sea bed to disturb the weed collected as little as possible so that the draping tendencies could be observed and the vulnerable parts of the equipment identified.

RESULTS

1.—*Vibration.*—The principal mechanical weakness indicated in the preliminary tests was excessive vibration at the cutter frequency employed (1000 cycles), causing the slacking off of nuts and ultimate failure of the gear. It was appreciated that this could be largely overcome by proper attention to balancing of the moving components, but to avoid interfering with the continuity of the trials, and to take advantage of the good weather prevailing at that time, the temporary expedient of fitting shock-proof washers, and checking the structure after each run, was adopted.

Although a number of runs were successfully completed in this way the evidence on examination between runs indicated a very real possibility of serious damage and the cutter frequency was consequently reduced to 800 cycles per minute.

During the second run at this reduced speed the cutter jammed, bending the activating crank and shearing a splined coupling in the flexible drive. The primary cause was found to be a bolt detached from its normal position and jammed between the back of the blade supporting-bar and a strengthening twist-bar at the corner of the leading frame. The secondary cause was the failure of the emergency slipping coupling to function properly at the resulting increased torque. Some difficulty had been experienced in setting this coupling to the required slipping torque, and shortly before the failure it had been tightened up slightly because of frequent slipping during normal operation of the cutters and consequent overheating; this undoubtedly contributed to its failure, and it was obvious that greater care would have to be taken to maintain the correct setting if a repetition of the failure was to be avoided.

Because of possible modifications as development proceeded, there was still little point in balancing the moving parts and further to reduce the vibration, which had almost certainly been the cause of the loosening of the bolt which jammed the cutters, the cutter frequency was again reduced, to 400 to 500 cycles per minute, and finally to 220 cycles per minute.

At this lower frequency there was a marked improvement in mechanical operation; only very occasionally was a bolt loosened during subsequent trials at 400 cycles per minute, and never at 220 cycles per minute. Difficulty was experienced, however, in operating at a boat/blade speed ratio within the effective cutting range, the lower limit being defined, in practice, by the minimum boat speed at which steerage could be maintained. This point is discussed in greater detail later in the report.

2.—*Cutter Protection and Prevention of Draping.*—To a large extent the measures normally taken to protect the cutters against damage are opposed to those for prevention of draping, i.e., the greater the degree of protection the greater the tendency to draping and " blinding " of the cutters.

The first arrangement of protective guards described under " Experimental Equipment," and shown in Figs. 1 and 5, certainly protected the cutters from damage but also, in spite of the steps taken to minimise draping by varying the extent of the upward and forward projection of adjacent main guards, prevented access of weed to the cutters.

After about twenty runs in which no weed was collected, the three main special tubular guards (5), Fig. 1, were removed, leaving a distance of 18in between main guards. A canvas lead-in was also fitted to prevent weed draping over the top and side members of the leading frame of the trawl.

The results of sixteen experimental runs of 60 yards each at a boat speed of 1·5ft per second showed a definite improvement had been effected by these modifications, the average weight of weed cut and collected in the trawl being about 100 lbs. As, however, this represented only 1·67 lbs per square yard, in a test area where the average density of growth of seaweed had been stated by Walker[4] to be 8 lbs per square yard at the depths in which the tests were conducted, these results were still far from satisfactory. Partly for this reason and partly because there was still evidence of weed draping, particularly on the small intermediate guards (6) six of these were replaced in two stages by guards of a modified design (14), Fig. 1, which were set below and slightly back from the leading edge of the cutting blades to permit cutting of the weed before draping could occur.

The results of the next two series of tests are compared with the previous series in Table I.

It is obvious from these results that the removal of three of the main guards and the redesign of alternate intermediates effected an appreciable improvement in the weight of weed cut and collected, which could only be due to a marked reduction in draping. This improvement, encouraging as it was, was still far short of a reasonable cutting efficiency when compared with the average density of growth in the test area, about 3 lb per square yard compared with 8 lb per square yard. It was suspected that the canvas lead-in was creating a wave action and deflecting an appreciable proportion of weed away from the trawl mouth. Before commencing the next series of tests, therefore, the canvas lead-in was removed. It was appreciated that troubles due to draping over the top leading members of the trawl would thereby be reintroduced but this was not considered important in the series of comparatively short runs contemplated compared with assessing its deflecting influence on weed being approached by the trawl.

Finally, two more of the large tubular guards were removed, leaving only the two outer ones formed by the structure of the trawl and the thirteen small intermediates with six of modified design (Fig. 3).

The results of tests to assess the effects of these later modifications are compared with the best results from Table I in Table II.

It was, at first, felt that these modifications would increase the vulnerability of the cutters but so far there has been no evidence of this. This can possibly be attributed to the robust nature of the reaper type cutters and the somewhat unusual conditions necessary

for damage to occur, viz., individual rocks with root cavities or forward sloping faces which pass between the main guards (4), allowing the small guards (14) to enter the rock cavities or to be clear of the root of the forward sloping face when the cutters themselves are in contact.

During the developments described above, modifications were also made to the equipment generally to facilitate handling of the trawl and to improve the experimental technique, and the stage was now reached where it was possible for the longer and more comprehensive investigations of the reaper type cutter to be undertaken.

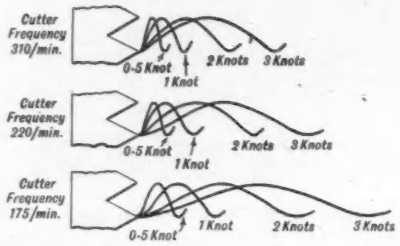
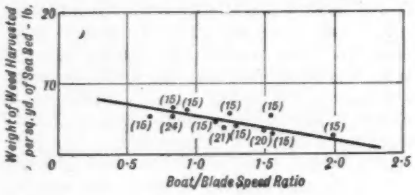
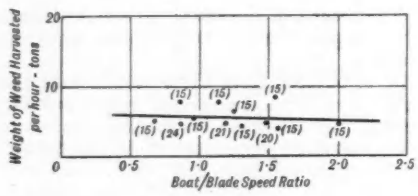
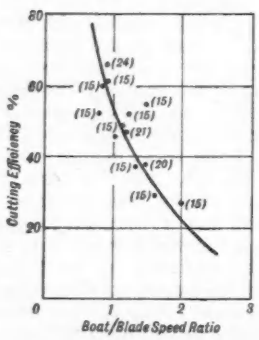


FIG. 6—PATH OF POINT ON REAPER CUTTER AT VARIOUS SPEEDS AND FREQUENCIES

3.—*Determination of Most Effective Boat/Blade Speed Ratio.*—The boat/blade speed ratio is obviously an important factor in any form of cutter, but particularly is this so in the case of the comparatively slow moving reaper cutter.







FIGS. 7, 8 AND 9—EFFECT OF BOAT/BLADE SPEED RATIO ON WEED CUT

Figures in parenthesis on all graphs indicate the number of experiments from which the averages plotted have been calculated.

In Fig. 6 the path of a point on the cutter has been plotted at various boat and blade speeds from which the tearing action at the higher boat/blade speed ratios is immediately apparent. The blade speeds chosen are those it was possible to attain with the experimental equipment in its final form.

It will be seen that as the speed of boat is increased relative to the cutter frequency, the tendency to bend the weed forward away from the cutters is increased, and it is conceivable that at the higher boat speeds a large proportion of the weed will consequently pass underneath the cutting mechanism.

To prove this in practice, and to determine the most suitable boat speeds and cutter frequency, these factors were varied in the final investigations and the results correlated and compared. Before commencing these investigations, the head room at the entrance to the experimental trawl was increased from 3ft 6in to about 6ft to prevent loss of weed over the top of the trawl which had occurred since removal of the canvas lead-in, and the cork floats were replaced by a buoyancy drum secured to the leading upper member to facilitate the overriding of obstacles on the sea bed. Three series of experiments

TABLE I—*Results of Tests to Determine Effect, on Quantity of Seaweed Cut and Collected, of Modifications to Design of Cutter Guards*

Length of run : 60 yards. Cutter frequency : 220 cycles per minute.
Boat speed : 1·5ft per second. Operating depth : 2·3½ fathoms.
Weed species : *Laminaria cloustoni*. Test Area : Off East Coast at Dunbar.

Run No.	Weight of weed cut and collected in pounds			
	Original design : four large regular tubular guards, three large special tubular guards, thirteen small intermediate guards	Three large special tubular guards removed, canvas " lead-in " fitted, otherwise as original	Alternate small intermediate guards replaced by modified design	
			First series, the guards replaced	Second series, six guards replaced
1	0	130	130	110
2	0	100	120	220
3	0	70	180	220
4	0	120	120	180
5	0	60	110	210
6	0	100	160	160
7	0	120	200	160
8	0	80	130	240
9	0	80	110	240
10	0	110	110	160
11	0	90	90	170
12	0	100	110	210
13	0	100	180	130
14	0	100	90	160
15	0	170	120	140
16	0	80	130	130
Average	0	100	130	177

TABLE II—*Results of Tests to Determine Effect on Quantity of Seaweed Cut and Collected, of Modifications to Travel Entrance and Design of Cutter Guards*

Test conditions as in Table I

Run No.	Four large regular tubular guards, thirteen intermediate guards with six of modified design. Last column in Table I	As previous column, but with canvas " lead-in " removed	As previous column, but with two more large tubular guards removed—leaving only outer main guards and small intermediates
1	110	120	340
2	220	250	180
3	220	180	210
4	180	200	320
5	210	180	160
6	160	190	360
7	160	260	260
8	240	190	220
9	240	300	260
10	160	260	230
11	170	240	220
12	210	210	160
13	130	220	310
14	160	270	270
15	140	260	160
16	130	160	160
17	—	260	—
18	—	290	—
19	—	140	—
Average	177	220	239

TABLE III

Length of run : 45 yards. Operating depth : 1½–3½ fathoms.
Weed species : *Laminaria cloustoni*. Cutter frequency : 310 cycles per minute.
Test area : Off West Coast of Argyll (Oban locality).

Run No.	First series			Second series			Third series		
	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb
1	1·6	0·62	220	2·5	0·96	280	2·7	1·04	280
2	1·5	0·58	360	2·1	0·81	190	3·0	1·16	160
3	1·7	0·66	180	2·1	0·81	260	3·0	1·16	520
4	1·7	0·66	210	2·3	0·89	480	3·0	1·16	240
5	1·8	0·69	290	2·1	0·81	280	3·0	1·16	100
6	1·7	0·66	270	2·3	0·89	300	3·0	1·16	240
7	1·8	0·69	180	2·1	0·81	350	3·0	1·16	140
8	1·7	0·66	230	2·3	0·89	320	3·0	1·16	120
9	1·8	0·69	270	2·1	0·81	270	2·7	1·04	90
10	1·9	0·73	220	2·3	0·89	280	2·7	1·04	260
11	1·8	0·69	200	2·1	0·81	260	3·0	1·16	300
12	1·7	0·66	220	2·1	0·81	310	2·7	1·04	280
13	1·9	0·73	330	2·1	0·81	230	2·7	1·04	180
14	1·9	0·73	200	2·3	0·89	210	3·0	1·16	190
15	1·8	0·69	210	2·3	0·89	500	2·7	1·04	190
Average	1·75	0·68	239	2·2	0·85	301	2·9	1·12	219

(45, 110 and 45 runs) were conducted at cutter frequences of 310, 220 and 175 cycles per minute, respectively, and at boat speeds between 1·5 and 3·0ft per second (0·88 and 1·77 knots). It was found to be impracticable to operate below 1·5ft per second, and still maintain steerage of the boat and it is, in fact, generally agreed by boat designers and masters that a speed of about 3 knots would be the minimum at which the size of boat envisaged for commercial harvesting could be manoeuvred with safety under the tricky navigational conditions prevailing in rocky coastal waters.

The results of these investigations are given in Tables III, IV, V and VI, and the average weight of weed cut per square yard of sea bed and per hour at various boat/blade speed ratios, are given graphically in Figs. 7 and 8. Finally, cutting efficiency is plotted against boat/blade speed ratio in Fig. 9.

Throughout this large number of runs on the sea bed there was no evidence of damage to the cutter blades or mechanism—and no mechanical troubles of any sort were experienced. Corrosion was effectively prevented by the use of a de-watering oil at the end of each day's operation.

TABLE IV

Length of run : 45 yards. Operating depth : 1½–3½ fathoms.
Weed species : *Laminaria cloustoni*. Cutter frequency : 220 cycles per minute.
Test area : Off West Coast of Argyll (Oban locality).

Run No.	First series			Second series			Third series		
	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed ft/sec	Boat/blade speed ratio	Weight of weed, lb
1	1·7	0·93	290	2·5	1·37	240	2·7	1·48	170
2	1·6	0·87	460	2·3	1·25	190	2·7	1·48	570
3	1·6	0·87	320	2·1	1·15	280	2·7	1·48	210
4	1·5	0·82	370	2·1	1·15	220	3·0	1·63	190
5	1·7	0·93	250	2·1	1·15	470	3·0	1·63	300
6	1·7	0·93	300	2·5	1·37	210	2·7	1·48	260
7	1·7	0·93	240	2·3	1·25	300	2·5	1·36	190
8	1·8	0·98	150	2·5	1·37	280	3·0	1·63	250
9	1·7	0·93	160	2·1	1·15	140	3·0	1·63	190
10	1·9	1·04	210	2·3	1·25	170	3·0	1·63	190
11	1·8	0·98	330	2·3	1·25	190	2·7	1·48	290
12	1·7	0·93	170	2·1	1·15	250	2·7	1·48	230
13	1·8	0·98	230	2·1	1·15	230	2·5	1·36	200
14	1·8	0·98	270	2·3	1·25	200	3·0	1·63	180
15	1·9	1·04	340	2·1	1·15	220	3·0	1·63	260
Average	1·7	0·94	273	2·2	1·23	239	2·8	1·53	245

TABLE V

Length of run : 45 yards. Operating depth : 1½–3½ fathoms.
Weed species : *Laminaria cloustoni*. Cutter frequency : 220 cycles per minute.
Test area : Off East Coast at Dunbar.

Run No.	First series			Second series			Third series		
	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb
1	1·5	0·82	310	2·1	1·15	150	2·7	1·48	190
2	1·7	0·93	510	2·3	1·25	170	2·5	1·36	90
3	1·5	0·82	420	2·3	1·25	180	2·7	1·48	120
4	1·7	0·93	310	2·1	1·15	140	2·7	1·48	90
5	1·7	0·93	240	2·3	1·25	120	2·7	1·48	120
6	1·6	0·87	220	2·1	1·15	170	2·7	1·48	70
7	1·7	0·93	210	2·1	1·15	160	2·5	1·36	130
8	1·6	0·87	220	2·1	1·15	130	3·0	1·63	180
9	1·5	0·82	180	2·1	1·15	110	2·7	1·48	70
10	1·7	0·93	200	2·1	1·15	190	2·7	1·48	90
11	1·6	0·87	180	2·1	1·15	220	2·5	1·36	120
12	1·7	0·93	270	2·3	1·25	80	2·7	1·48	160
13	1·5	0·82	260	2·3	1·25	160	2·5	1·36	240
14	1·6	0·87	210	2·3	1·25	270	2·7	1·48	250
15	1·6	0·87	300	2·3	1·25	180	2·7	1·48	90
16	1·5	0·82	200	2·3	1·25	280	2·7	1·48	210
17	1·6	0·87	350	2·1	1·15	200	2·7	1·48	190
18	1·5	0·82	190	2·3	1·25	140	2·7	1·48	200
19	1·7	0·93	110	2·3	1·25	140	2·7	1·48	180
20	1·6	0·87	230	2·1	1·15	230	2·7	1·48	60
21	1·7	0·93	220	2·1	1·15	190	—	—	—
22	1·7	0·93	160	—	—	—	—	—	—
23	1·6	0·87	180	—	—	—	—	—	—
24	1·6	0·87	80	—	—	—	—	—	—
Average	1·6	0·87	240	2·19	1·19	172	2·7	1·46	142

TABLE VI

Length of run : 45 yards. Operating depth : 1½–3½ fathoms.
Weed species : *Laminaria cloustoni*. Cutter frequency : 175 cycles per minute.
Test area : Off West Coast of Argyll (Oban locality).

Run No.	First series			Second series			Third series		
	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed ft/sec	Boat/blade speed ratio	Weight of weed, lb	Boat speed, ft/sec	Boat/blade speed ratio	Weight of weed, lb
1	1·8	1·23	140	2·3	1·57	140	3·0	2·05	130
2	1·8	1·23	90	2·1	1·44	90	2·7	1·85	110
3	1·9	1·3	130	2·3	1·57	180	3·0	2·05	100
4	1·7	1·16	340	2·5	1·71	160	3·0	2·05	80
5	1·8	1·23	350	2·3	1·57	60	3·0	2·05	90
6	1·6	1·1	130	2·5	1·71	130	2·7	1·85	110
7	1·6	1·1	140	2·5	1·71	70	2·7	1·85	100
8	1·7	1·16	220	2·1	1·44	100	3·0	2·05	120
9	1·6	1·1	110	2·1	1·44	80	3·0	2·05	80
10	1·8	1·23	130	2·3	1·57	120	3·0	2·05	230
11	1·8	1·23	170	2·1	1·44	110	3·0	2·05	170
12	1·7	1·16	140	2·3	1·57	190	3·0	2·05	140
13	1·9	1·3	210	2·1	1·44	170	2·7	1·85	170
14	1·9	1·3	110	2·1	1·44	170	2·7	1·85	130
15	1·8	1·23	90	2·5	1·71	160	2·7	1·85	100
Average	1·76	1·2	167	2·3	1·56	129	2·9	1·97	124

CONCLUSIONS

The work described in this report has shown that a reaper type reciprocating cutter, mounted and protected against damage by rocks as described, is a suitable device for cutting whole brown seaweed plants of the *Laminaria cloustoni* species from the sea bed.

It has been found that the cutting efficiency tends to decrease with increase in boat/blade speed ratio ; at the lower values used (0·68 to 0·93) efficiency was 60 per cent of theory, equivalent under test conditions, to about 5 tons of weed per hour. In dense weed beds up to about 10 tons per hour may be harvested.

The limiting factors appear to be the boat speed at which steerage can be maintained and the maximum cutter frequency at which reliable and safe operation is possible, and there is evidence that cutting efficiency, which is largely dependent on boat/blade speed ratio, will have to be sacrificed to some extent to meet these conditions.

Apart from the single cut which severed the plant from the sea bed and which was usually about 12in from the holdfast, the weed was not damaged by this method of cutting. At the same time, if suitable means of preserving wet weed can be found, there are many advantages in cutting the plants into smaller pieces in the cutting and entrainment system of harvesting.

ACKNOWLEDGMENT

The work described in this report forms part of the programme of research and development on seaweed undertaken by the Institute of Seaweed Research to whom the authors are indebted for permission to publish.

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LECTURE COURSES AT THE ROAD RESEARCH LABORATORY.—Lecture Courses will be held at the Road Research Laboratory, Harmondsworth, during the autumn and winter of 1952–53. As in previous years they will deal with the fundamental properties of road materials and their application in modern practice, and will include the most recent results of research. The courses start in October and are devoted to soil mechanics, concrete and tar and bituminous materials. The second bituminous materials course will be slightly modified in order to include a symposium which will afford extended consideration of surface dressing. Each course will be self-contained and a fee of £10 10s. will be charged for it. Forms of application may be obtained from the Director, Road Research Laboratory, Harmondsworth, Middlesex. A two-days course on the stabilisation of soil with cement has also been arranged in co-operation with the Cement and Concrete Association, and will be held on August 20th and 21st at the Association's Training Centre, Wexham Place, Stoke Poges, Bucks (near Slough), from which particulars can be obtained. There is no fee for this course.

Non-Sparking Tools

By L. BERNHARDT, B.Sc. (Eng.), A.M.I.Mech.E.*

In a number of industries making or using inflammable materials it is very undesirable to use tools prone to create sparks when struck against stones, concrete and other materials. Suitable tools may be made of beryllium copper, aluminium bronze, Monel metal and other non-ferrous materials. A plea is made that tests should be carried out to ascertain, more precisely, the impact sparking properties of various tool materials and to determine over what range of concentrations various explosive mixtures are capable of being ignited by sparks.

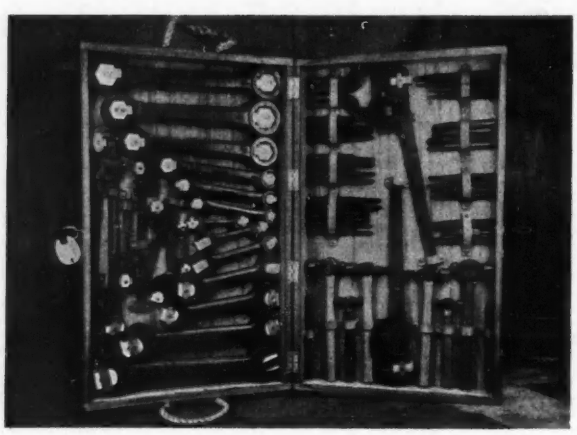
A FIRE or explosion in factory or oil refinery affects not only the dead and the injured and their families but also many other interested parties. While insurance companies may pay for the direct damage, all accidents are inevitably followed by loss of production and revenue. Furthermore, the psychological effect on those who work in fear of similar accidents cannot be disregarded.

In a large number of industries inflammable and explosive materials are manufactured or employed and it is therefore obviously imperative to prevent the use of naked lights or flames and the occurrence of electric sparks. In addition, frictional and impact sparks present an ignition hazard. It is well-known that hot, bright sparks are easily produced when a piece of steel is pressed against a grinding wheel. Similarly, sparking commonly occurs when steel tools, such as pickaxes or cold chisels strike against stone or concrete. Therefore, in order that tools may be used with safety in the above mentioned industries they should not be made of steel.

The main reason why ferrous metals are prone to sparking is the ease with which iron oxide is formed in air when iron particles are detached on impact. The particles are first preheated by the energy required to tear them from the parent metal. The oxidation which subsequently occurs is markedly exothermic (1600 calories per gramme) and the temperature of the particles is rapidly raised to incandescence. On the other hand, the heat of formation of copper oxide, for example, is only 314 calories per gramme. Other properties of metals, such as ductility, hardness, thermal conductivity, specific heat and the affinity for oxygen at medium temperatures, are also factors which determine their suitability for safety tools.

Whilst it has long been known that most non-ferrous metals are practically non-sparking, their relatively low strength and hardness have ruled them out for the majority of tool applications. The position has changed, however, with the development of stronger and tougher metals, such, for instance, as beryllium copper (a copper-base alloy containing about 2 per cent of beryllium) and aluminium bronze, a copper-base alloy containing some aluminium, nickel and iron.

The first use of beryllium copper for tools dates back to the nineteen-thirties and since that time tools have also been made from other improved copper alloys. Nickel-base alloys and aluminium-base alloys have been tested but were found to be rather more prone to sparking than the copper alloys. Trends in the United States seem to indicate that the competitive struggle between the various alloys is being decided in favour of beryllium copper and aluminium bronze, though tools made from Monel, a nickel alloy, are recommended in certain special cases where the corrosion resistance of other metals is inadequate. Tools with cutting edges, such as chisels, drills, knives, saws and shears, and tools like pipe wrenches and pliers which have gripping teeth, are best made of beryllium copper, the exceptional strength and hardness of which most closely approach those of steel. On the other hand, in the case of hammers, spanners, rakes, trowels, wedges, crowbars and similar tools, where less severe demands on the tool material are made, aluminium bronze may give satisfactory service and is less costly than beryllium copper. However, tools are sometimes unnecessarily strong for the duties which they perform and their cost might be reduced by lightening them. In Great Britain only beryllium copper non-sparking tools are at present manufactured and used in quantity. A typical tool-kit, made by the Telegraph Maintenance and Construction Company, Ltd., for use on oil field installations, is shown above.



BERYLLIUM COPPER SAFETY TOOL KIT.

Average values for the mechanical properties of some non-ferrous alloys, which are tabulated below, demonstrate the superiority of beryllium copper, though the other alloys are also very hard and strong.

Unfortunately, the sparking properties of metals cannot be determined so easily as their mechanical properties. At one time sweeping claims were made in America that the use of proprietary non-ferrous alloy tools ensured absolute freedom from sparks. Fortunately a more sober viewpoint predominates to-day and it is realised that the composition of the tools is not the only criterion which determines the occurrence of sparks. Thus, when particles are removed from steel or iron bodies by impact, sparks may be produced due to the heat of oxidation of the iron, regardless of the kind of tool employed. It is undoubtedly true, however, that even in such circumstances the risk of explosions is considerably reduced by the use of non-ferrous tools and that particles dislodged from such tools very rarely give rise to sparks. It is indeed probable that the impact of certain copper alloys on ferrous metals will not cause sparks at all.

It is not possible, unfortunately, to make authentic statements about the relative sparking properties of non-ferrous metals since relevant test results are not available. Red glow or sparks can be produced easily when any one of a large variety of metals is held in heavy frictional contact with metal or abrasive wheels. This is, however, an exceedingly severe test, which bears little relation to the operating conditions of hand tools in industry, since any possible sparks from such tools are due to impact rather than friction. It is therefore regrettable that in the only systematic series of trials carried out in this country, specimens of various metals were applied to the surfaces of rotating wheels of eight different materials, thus testing for frictional rather than for impact sparks. The results of these experiments show that, among the wide range of copper alloys tested, the only ones susceptible to frictional sparking were 90/10 cupronickel and beryllium copper, the latter only when in contact with ferrous rotating wheels. None of the eleven bronzes and brasses tested produced any sparks. On the other hand, tools made of Monel, mild steel and stainless steel were found to be particularly prone to sparking and Duralumin and aluminium rather less so.

The fact that sparks may be produced by tools does not mean that a fire or explosion will result as a matter of course if they are used in an inflammable atmosphere. Much depends on the temperature at which a given combustible mixture will ignite. In order to raise the temperature of the

Mechanical Properties of Some Non-Ferrous Alloys

Material	U.T.S. Tons per square inch	0·1 per cent Proof stress, tons per square inch	Elongation, per cent on 2in	Hardness, Brinell
Beryllium copper (heat-treated castings or forgings)	80–90	66–70	2	360–400
High nickel alum nium bronze forgings ...	55–60	40–50	12–20	240–270
Aluminium bronze forgings to D.T.D. 197A	45–52	25–34	15–25	180–240
Aluminium bronze forgings to D.T.D. 164A	38–48	20–25	18–25	150–210
Monel (3·75 per cent Si) cast	40–45	40–45	0–4	230–300
Monel forgings	34–38	15–18	30–40	120–140
Monel castings	23–33	11–15	20–40	100–140

* Copper Development Association

gas or vapour to the ignition point the sparks must reach an even higher temperature. In addition, their heat content above the ignition temperature must be sufficient to allow the necessary amount of heat to be transferred to a minimum volume of the mixture. It is obvious, therefore, that in view of the cooling effect due to convection, flying sparks are less dangerous than those whose path is obstructed by a thermal insulator at an early stage.

Among the gases and vapours which will ignite at comparatively low temperatures are ethyl nitrite, carbon disulphide, ethyl ether, hydrogen and acetylene. Petroleum vapours, town gas, methane and other gases are inflammable in varying degrees. Metals (such as magnesium, aluminium, &c.) in powder form and coal, sugar, grain or flour dusts also form highly explosive mixtures with air. In each case certain concentrations of gas or powder in air are the most dangerous. Apart from the explosives, gas, and oil industries, fire and explosion hazards exist in many others, including works manufacturing paint, lacquer, matches, spirits and certain kinds of food.

It is obviously desirable that tests should be carried out to ascertain the impact-sparking propensities of various tool materials with varying load intensities. Furthermore, it would be useful to determine over what range of concentrations various explosive mixtures are capable of being ignited by mechanical sparks. There is, however, no doubt that beryllium copper and other copper alloy tools are much safer to use than tools made of steel even though an accurate assessment of their relative sparking properties is not yet possible.

A Modified Farnboro Electric Indicator*

By W. J. R. ROACH, B.Sc., and J. G. G. HEMPSON, A.M.I.Mech.E.

No. I

The development of an apparatus and operating technique for determining the mechanical efficiency of large marine oil engines is described and the shortcomings of existing equipment for measuring indicated mean effective pressures are discussed. There is a description of a modified Farnboro indicator which makes use of the movement of a flexible diaphragm to initiate signals to an electronic relay, which causes time and pressure to be recorded. The torsional rigidity necessary in the indicator drive is noted and also the need for accuracy in marking dead centres.

THE apparatus described has been developed to assist in the determination of the mechanical losses in large marine oil engines on the test bed and at sea. During these tests the equipment has been found capable of recording low-pressure phenomena such as occur in engine cylinders during the exhaust and scavenging periods. The large size and low speed of main propulsion oil engines preclude the accurate estimation of mechanical losses by the methods employed for testing small high-speed engines, and the motoring of an engine designed to develop, say, 6000 s.h.p. at 120 r.p.m., would entail a power supply exceeding that normally available on a test bed. Similarly, an indirect procedure, such as that of cutting out cylinders and noting the fall in power output at constant speed, would take so long that it would be incorrect to assume constancy of internal conditions. A direct approach to the problem was decided upon, i.e. the measurement of output and of indicated power. With modern equipment a measurement of output can be obtained with satisfactory accuracy.

For the estimation of indicated mean effective pressures a greater accuracy was required than could be attained by any of the existing methods of measurement.

An examination of published information together with figures obtained during the course of the development here described showed that a displacement of 1 deg. of crankshaft rotation of the position of the top or inner dead-centre line on an indicator diagram was sufficient to cause an error of the order of 5 per cent in the measured mean pressure.

Under controlled conditions and with a drive theoretically and mechanically sound results of value for comparative purposes can be obtained by a piston indicator, but when absolute figures are to be determined this indicator is considered incapable of consistently providing the required accuracy. In some cases it has proved virtually impossible to obtain an indicator card free even from obvious defects.

The next instrument to be considered was the cathode-ray oscilloscope, operating in conjunction with pressure-sensitive elements. This equipment is unrivalled for the qualitative examination of engine performance, although with slow-speed engines the limited persistence of vision of the human eye and luminous screen makes inspection difficult. The approach to quantitative investigation brings to light a number of possible sources of error, and for the purpose of power measurement, the inaccuracies and random errors produced by zero drift, difficulties in phasing, the small size of diagram, and the various processes of photographic recording and reproduction showed that this indicator was unlikely to satisfy the requirements. Regarding the point-by-point method of progressively plotting the balance points of cylinder pressure and a known applied pressure against crank angle, the supposed accuracy of this method is nullified when applied to slow-moving engines by two factors: the long time taken to obtain even one diagram (of the order of 15 minutes) and the excessive fouling of the cylinder pressure-sensitive units when exposed to the combustion conditions of a slow-running engine burning relatively heavy fuel oil.

Consideration was then given to the Dobbie McInnes Farnboro indicator. The diagram obtained is of large size, the time base is accurate and linear, and in the recording motions no part is required to move in step with any cyclic variation of engine conditions except the drum, which is rotated by the engine. The pressure-recording mechanism can be calibrated with a high degree of accuracy, and

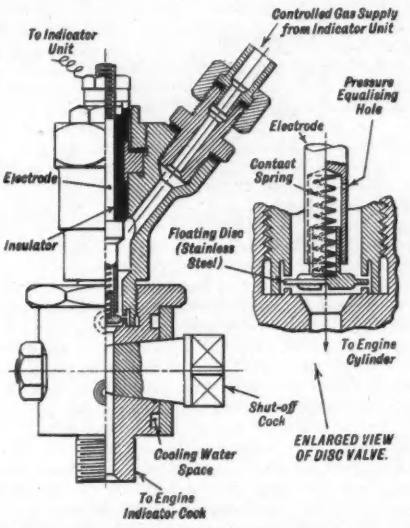


FIG. 2—FARNBORO DISC VALVE UNIT

the marking of the diagram is carried out by a frictionless process, i.e. perforation of the paper by an electric spark. Against these advantages must be set poor definition, the line of spark perforations showing considerable scatter, and the erratic behaviour of the pressure unit in the engine cylinder head.

In this apparatus the time is recorded, in terms of crank angle, at which the cylinder or other pressure to be determined is balanced by an adjustable and known applied pressure. For any specific applied pressure, within the limits of maximum and minimum, there will be at least two balance points in each cycle, one when the unknown pressure is rising and another when it is falling. By commencing

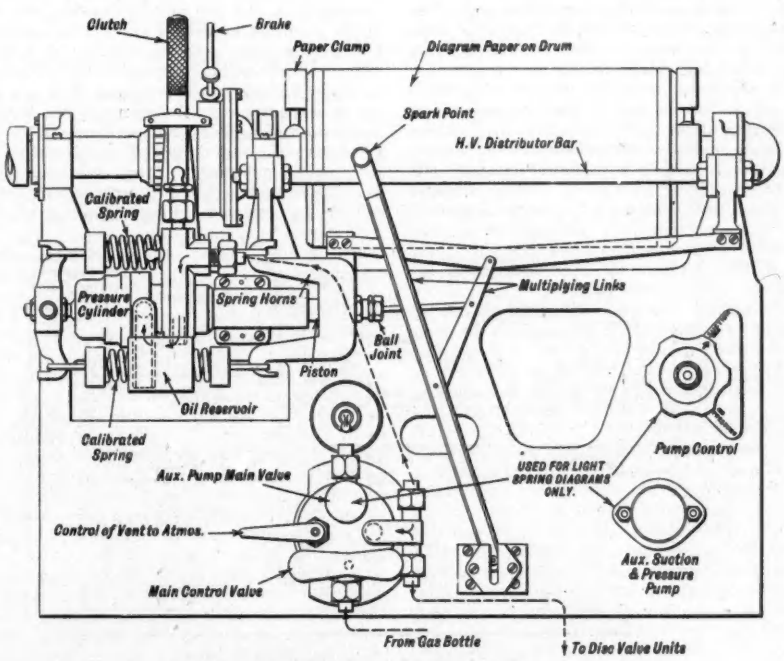


FIG. 1—FARNBORO ELECTRIC INDICATOR RECORDING UNIT

* British Shipbuilding Research Association Report No. 92.

with atmospheric or sub-atmospheric applied pressure and gradually increasing it, a set of time records may be obtained covering the whole range of the cyclic pressure variation it is desired to determine. The resulting diagram is thus built up over a considerable number of cycles, and the unknown pressure phenomena must be cyclic within the limits of practical engine testing. In the original apparatus the point of pressure balance was signalled to the recorder by an electrical change in a circuit due to the movement of a free floating disc in the pick-up unit mounted in the cylinder head or other portion of the engine. This disc was subjected on the one side to the unknown variable pressure and on the other to the known applied pressure and, together with its seatings on either side, formed a part of an electrical circuit. The change of differential pressure from positive to negative was accompanied by a movement of the disc from one seat to the other, thus interrupting the electric circuit. This caused a spark between the spark point and the recording drum, the former being moved axially in relation to the rotating drum by the steadily increasing applied pressure. The drum carried a specially prepared paper and was rotated at engine speed or at half engine speed and a pressure-time diagram was thus built up. A general view of the Farnboro disc-valve unit is shown in Fig. 2 and of the recording unit in Fig. 1. As far as was known the Farnboro indicator had not previously been employed for the testing of large slow-running oil engines and preliminary trials were arranged to determine the durability of the equipment and which portions would need modification. The diagrams obtained showed the inherent suitability of the instrument but indicated many points requiring attention.

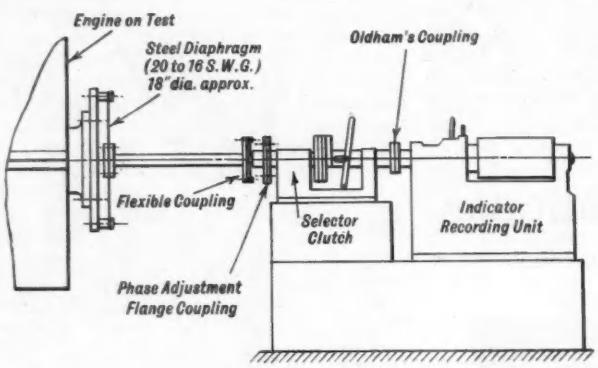


FIG. 3—DRIVE TO INDICATOR

The Farnboro indicator was developed for the purpose of indicating high-speed internal combustion engines. When fitted to a marine oil engine certain differences are apparent: electric leads and high-pressure pipe-lines are long, of the order of 75ft to 150ft, compared with about 10ft with a high-speed installation; very little medium or high-frequency vibration is transmitted to the indicator; the speed of rotation of the indicator drum is low and cyclic torque fluctuations are accentuated. The effect of the long electric leads was readily overcome by suitable adjustments to the internal electrical components, but the length of piping meant that no appreciable leakage past the floating disc in the pick-up unit could be tolerated, as this might cause an unacceptable pressure gradient along the piping, the recorded pressure being then higher than that applied to the unit. The lack of vibration caused the mechanical linkages in the recorder to behave sluggishly and to show a jerking motion in spite of precautions to eliminate friction and misalignment. The low speed of drum rotation directly influenced the recording of the diagram, as the applied gas pressure could only be raised at a low rate in order to outline the diagram with a sufficient number of spark perforations. This low rate of pressure rise was desirable with lengthy pipe-lines for the purpose of reducing flow rate and the effects of pressure drop. An additional problem was that at low speeds the effect of cyclic variations was directly evident in chatter and surging in the drive and indicator clutch.

Although it proved possible to obtain fairly clear diagrams of the pressure phenomena occurring in the engine cylinders attention was concentrated on the development of a different balance-indicating unit for the apparatus. With the original Farnboro disc valve, trouble was experienced due to gas leakage, overheating, contact-face corrosion and internal fouling, in spite of the use of nitrogen for applying the known pressure.

Consideration of all factors led to the abandonment of the normal disc-valve unit and the development of a new balance-indicating unit, incorporating a relatively large and very flexible diaphragm, and other modifications.

A preliminary specification of requirements was drawn up and this made the following points regarding the pick-up unit: the unit must provide a complete seal between combustion or other gas spaces and the controlled pressure supply; no operation should be necessary to put the unit in action; the construction must be robust enough to withstand the handling likely to be experienced in practice; dismantling for cleaning should be possible without requiring great skill or subsequent adjustment; the operation of the unit must approach being independent of the rate of change of pressure and of working with zero differential pressure; the unit should be insensitive to the effect of varying temperature within the operating range; the connection between the unit and any electronic relay must be insensitive to electrical interference of all kinds and not affected by low ohmic leakage values; the unit should be capable of operating for a period of about eight to ten hours under severe conditions without the need for servicing.

The probable necessity for an electronic relay was recognised as the relatively short life of the original Farnboro disc-valve contacts is in part due to arcing arising from the relatively large current and consequent high induced voltages of the simple circuit employed with it. The electronic apparatus would have to fulfil the following requirements: it must be compact, use standard components and have a minimum of adjustments. The relay must be robust, be insensitive to considerable supply voltage and frequency fluctuations, and also to the variable values of cable insulation, resistance, capacitance, &c., likely to be experienced in application.

Favourable factors in the original specification were that the size of pick-up unit was not important and that the equipment was required primarily for use with engines running at speeds below 600 r.p.m.

Experienced in service shows that the conditions have been met practically completely and the results encourage extension of the use of the apparatus.

THE DRIVE TO THE INDICATOR

In previous applications a variety of types of drive have been utilised with the Farnboro indicator. These have included the following: chain and sprocket drive from crankshaft, camshaft, or layshaft; extended shaft fitted with universal joints; fabric coupling; slot and pin coupling; standard fuel-injection pump coupling; Vernier type coupling.

The mechanical connection of the indicator drum to a slow-running marine oil engine has to allow for factors which are of little consequence when dealing with high-speed engines. The long lengths of shafting necessitate a consideration of torsional deflections. From observations made on the overall twist of various portions of an engine the only solution was to drive the indicator direct from the free end of the crankshaft by means of a shaft and couplings of high relative torsional rigidity; but, owing to movements of crankshaft and indicator seating, axial and lateral flexibility was required. The arrangement shown in Fig. 3 has proved entirely satisfactory.

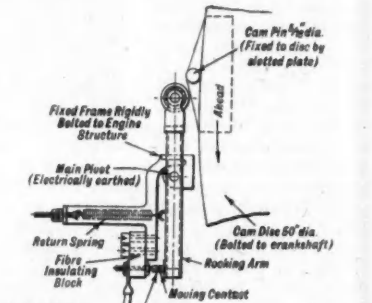


FIG. 5—CONTACT BREAKER FOR TOP DEAD CENTRE MARKER

The diaphragm attached to an extension on the end of the engine crankshaft allows for fore-and-aft relative movement between the crankshaft and indicator and, in conjunction with the smaller diaphragm coupling, permits considerable misalignment. This has simplified the setting up of the apparatus. Spring-steel diaphragms are desirable for the smaller coupling, as fatigue cracks have appeared on some occasions when mild steel diaphragms have been fitted. No trouble has been experienced with mild steel for the larger diaphragm attached to the engine crankshaft. In order to reap benefit from the vibrator unit described later it has proved undesirable to provide a very rigid mounting for the indicator itself.

Where space permits it is an advantage to

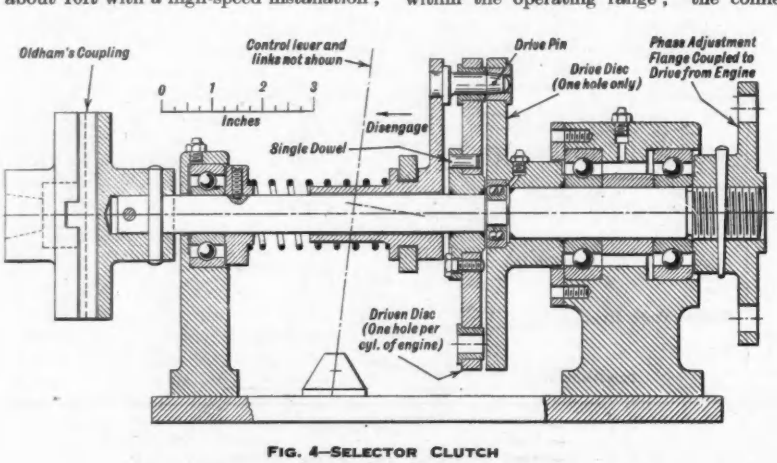


FIG. 4—SELECTOR CLUTCH

incorporate a selector clutch in the drive to the indicator. This clutch, shown in Fig. 4, brings to the centre of the paper the pressure diagram for each cylinder as it is indicated. In this clutch the engine drives a disc having in it a single hole at 2¼in radius from the axis. This hole, formed in a hardened-steel bush, has a fine taper. Opposing this driving disc is another disc, connected to the indicator shaft through an Oldham coupling, which has holes in it spaced according to the crank relationships of the engine. The holes in this disc are not tapered. A spring-loaded arm is located on the shaft between the driven disc and the indicator coupling and carries a peg which can pass through any hole in the driven disc and engage with the single tapered hole in the driving disc. The angular position of the indicator drum can be altered relative to the engine crankshaft while the engine is running, shock effects of engagement not having proved a handicap at up to 225 r.p.m.

In both selector clutch and Oldham coupling backlash is at a negligible minimum and does not interfere with the torsional rigidity of the drive as a whole. The omission of the selector clutch due to lack of space for certain trials has had no ill effects on the accuracy of measurement of the diagrams, as only about ¼in of diagram is lost at the paper joint, and the clarity of the diagrams has permitted accurate interpolation for this short distance. The diaphragm coupling to the selector clutch incorporates a pair of slotted flanges allowing angular adjustments over a complete revolution for the purpose of setting the indicator in the first place.

The Marking of Dead Centres

Attention has been drawn to the necessity for an accurate indication of the dead centres when mean-pressure determinations are undertaken. Following an examination into the possible accuracy of measurement of diagrams, it was decided that the error in dead-centre marking on the diagram should not exceed ±0·1 deg. of crank angle. This would limit the error in mean-pressure measurements from this cause to a maximum of about ±½ per cent, and to a linear measurement of 0·004in on the periphery of the Farnboro recording drum.

The method of indicating dead centres has been to utilise some standard type of contact breaker to produce an electric pulse. In the original Farnboro equipment this pulse has been utilised to cause a spark at the recording drum. It is difficult to maintain phasing even within ±1·5 deg. over periods of running, and work was carried out to enhance the accuracy of this simple method. A 50in diameter disc carrying a cam to operate a pivoted lever contact breaker was fitted to the crankshaft on a large engine running at about 110 r.p.m. This is shown in Fig. 5. Although this was an improvement, such variables as crankshaft whip and internal twist (transient values of up to ½ deg. have been measured) cast doubts on the final accuracy. This led to a decision to cause the piston, or some convenient portion of the motion rigidly connected to it, to signal its exact time of passing a known point.

The risk of initiating a crankcase explosion precluded the use of any contact breaker inside the crank chamber of an engine and attention was concentrated upon available electromagnetic apparatus. The limitations of simple electronic circuits where the measurement of amplitude is concerned decided that the use of such apparatus would be limited to the indication of the time at which any specific phenomena occurred.

The result of the work on this problem is the use of electromagnetic pick-up units, such as those used for providing degree marking with cathode-ray oscilloscope apparatus, in conjunction with chisel-pointed mild steel pegs attached to the portions of the engine whose motion it is required to record. The pulse generated by each passage of a peg past a pick-up unit is taken to the electronic relay and the latter causes a spark at the recording drum.

This apparatus may be employed in three ways for the indication of dead centres. These may be summarised as follows: (*a*) the electromagnetic units are mounted inside the engine crankcase and a steel peg is attached to one crankweb of each cylinder line, coincidence of peg and the chisel-pointed magnet being arranged to occur at exactly the required dead centre; (*b*) the electromagnetic units are mounted in the crankcase and the pegs attached to either piston skirts or crossheads so that coincidence is obtained at a little before half-stroke, i.e. when the piston is moving with approximately its maximum velocity; (*c*) for opposed-piston engines with external rods operating one piston in each cylinder a simpler set-up may be employed. In essentials this method is identical to (*b*) but the pegs are attached to the external upper pistons or to the side rods operating them, the electromagnetic units being mounted on the engine framing or entablature.

Two disadvantages are apparent in method (*a*), the first being the difficulty of setting the engine accurately on the required dead centre, since turning gears fitted to slow-speed marine engines are insensitive to control. The other disadvantage is that the magnetic units must be secured inside the crankcase. Against these drawbacks an argument in favour of method (*a*) is the resulting single line on the diagram marking the passage of the piston through the dead centre.

Method (*b*) necessitates the provision of internal brackets, but they may be in a more accessible position. No setting of the piston on a dead centre is required. Two lines appear on the indicator diagram, one produced when the piston is on its outward stroke and the other when on the inward stroke, in both cases the relative velocity being at or near the maximum. If the cylinder centre line is not offset from the crankshaft the dead centres on the diagram will be exactly halfway between the two "reference" lines.

The marking obtained from method (*c*) is identical with that from (*b*) but the same rule for positioning the dead-centre lines will only be applicable if the two pistons in each cylinder are exactly in phase. This method is the most convenient for assembly since all parts are external to the crankcase.

If a gap of not more than 0·050in exists between peg and magnetic unit at coincidence an ample pulse is produced for the purpose of triggering the relay. In practice a setting of about 0·020in is normal. At the radius of the crankpin in most large marine engines 1 deg. of crank angle is equivalent to 0·3in to 0·4in circumferential length.

(To be continued)

Franco-British Television

Since the demonstration at Alexandra Palace on April 21st at the conclusion of the technical tests between Paris and London, discussions have continued between engineers of Radiodiffusion et Télévision Françaises (R.T.F.) and the B.B.C. It has been concluded that the technical methods adopted during the test period were basically satisfactory, and it is intended to follow the same methods for the week of the joint Franco-British programmes from July 8th to 14th. The technical arrangements will therefore be as briefly follows.

From the outside broadcast points in Paris vision signals will be conveyed to a receiving point at the Eiffel Tower by radio link. Three 9000 Mc/s radio link units, manufactured by the Compagnie des Compteurs, will be used. The programmes will be broadcast to French viewers in the Paris Region from the two R.T.F. transmitters in Paris, one operating on the 819-line system and the other on the 441-line system (the old French standard). The R.T.F. convertor developed by the French firm Radio Industrie will be used to convert the 819-line pictures to the 441-line standard.

From Paris to Lille, a distance of 136 miles, the 819-line vision signals will be carried by the R.T.F. experimental radio link with intermediate stations at Villers-Cotterets (44 miles north-east of Paris) and Sailly-Saillissel, near Peronne (50 miles from Villers-Cotterets and 42 miles from Lille). This radio link, which works on a frequency of about 900 Mc/s and was manufactured by Compagnie Française Thomson-Houston, is used by R.T.F. to supply programmes to the Lille television transmitter until the permanent radio link now being installed by the French Post Office is ready.

The programmes will be broadcast from the R.T.F. transmitter at Lille for the benefit of viewers in that area. The Lille transmissions on 180 Mc/s approximately will be picked up at Cassel by a special receiver manufactured by Societe Desmet. R.T.F. will also install a temporary radio link working on 9000 Mc/s approximately, manufactured by Compagnie des Compteurs. The signals thus received will be fed to the convertor developed by the B.B.C. Research Department, for changing pictures from French standards to British standards (from 819 to 405 lines).

The 18 miles between Cassel and Alembon will be covered by a B.B.C. radio link on about 7000 Mc/s, using equipment manufactured by Marconi's Wireless Telegraph Company, Ltd. Between Alembon and Dover, a distance of 40 miles, there will be a B.B.C. radio link on about 4500 Mc/s, with equipment manufactured by Electric and Musical Industries, Ltd. The same company is responsible for the equipment of the B.B.C. radio link on about 4500 Mc/s between Swingate and Wrotham (49 miles).

Finally, for the B.B.C. radio link on about 4500 Mc/s between Wrotham and London (23 miles), the equipment was manufactured by Standard Telephones and Cables, Ltd.

Work on the installation and testing of the convertor at Cassel and of the temporary links between Cassel and London started on June 19th, and this work will continue up to the date of the first programme transmission. Independently, programme rehearsals will be going on in Paris from July 1st and July 7th inclusive. Technical responsibility for the camera equipment and for the picking up of programmes in Paris will be in the hands of R.T.F. At various times during the week July 8th to 14th, four different types of camera equipment will be used, namely: Pye, Ltd., "Image-Orthicon"; Radio Industrie, "Image-Orthicon"; Compagnie Française Thomson-Houston, "Photicon"; Radio Industrie, "Image-Iconoscope."

Concrete Shell Roofs

A symposium on concrete shell roof construction, organised by the Cement and Concrete Association, is being held during this week. It opened on Wednesday last, when three papers concerned with the architectural aspects of this class of construction were presented at the Royal Institute of British Architects. Yesterday, five papers devoted to the more theoretical aspects of shell roofs were presented at the Institution of Civil Engineers, and to day four papers on construction and formwork will be read, also at the Institution of Civil Engineers. The titles of Thursday's papers on design and research were as follows:—"Existing Methods for the Analysis of Concrete Shell Roofs," by J. J. McNamee; "Flexibility Coefficient Methods and Their Application to Shell Design," by A. Goldstein; "Research on Shells," by P. B. Morice; "Theories of New Forms of Shell," by R. S. Jenkins; and "The Combination of Shells and Prestressing," by C. V. Blumfield. The constructional problems of shell roofing are to be discussed to-day with the presentation of four papers entitled: "Design and Construction from the Economic Aspect," by H. G. Cousins; "Construction of Skelton Grange Power Station at Leeds and a Factory at King's Lynn," by H. E. Manning; "Formwork Used on a Factory at Greenford," by H. F. Rosevear; and "Travelling Formwork as Used on Sheds at Antwerp," by A. Paduart. The papers give many examples of shell-roofed structures, both in this country and overseas, and the proceedings of the symposium will doubtless form a valuable and comprehensive reference for this new and popular form of construction.

Research Laboratories of Babcock and Wilcox, Ltd.

No. II—*(Concluded from page 857, June 27th)*

In 1950 Babcock and Wilcox, Ltd., acquired new premises for use as research laboratories about 1¼ miles from the main Renfrew works. Research work, carried on in laboratories at the Renfrew works and in various departments of that works, has been transferred to the new premises, and new research buildings are to be built to expand the floor area available. A short account is here given of what was seen during a recent visit to the new laboratories.

Fuel Testing

The minds of many engineers have been exercised for the last two centuries or so as to how best to obtain a fair sample of the coal burned in a boiler efficiency test. For it is a very far from easy problem to reduce the many hundreds of tons of fuel that may be used in a modern test to a fair sample, for final analysis, weighing only a gramme! In the fuel testing section we were able to see how fuel samples received are first dried in an oven and then ground in small mills. The size of the sample is reduced between successive grindings by the use of a rotary sampler. This device consists of a wheel having a number of compartments, each of which passes in turn beneath the hopper through which the ground coal falls—Fig. 7. By the use of a spring flap the coal falling into any compartment can be directed into the inner or outer of two concentric conical hoppers below. Thus, by suitably setting the flaps, the sample can be halved, or a third, a quarter, or a sixth directed into one hopper and the remainder into the other. The accuracy of sampling attained is said to approach closely the theoretical. Analysis of samples thus obtained follows the usual course, the only points worth mentioning here being that a telescope mounted outside a draughtproof cabinet is used for thermometer readings when the calorific value is being determined in a bomb type calorimeter, that the mercury thermometer is sensitive to 0·001 deg. Fah., and that a mechanical "flapper" driven by electric motor can be used to tap the thermometer gently to prevent any sticking of the mercury.

Fig. 7—Coal Sampling Room

Fig. 8—Water Evaporation Apparatus

Ash and slag investigations are also carried out in this department. So, too, are researches into water purity. Here, where close accuracy is needed, certain difficulties are encountered if large quantities of condensate are to be evaporated to dryness in order to measure salts that may be present in quantities of less than one part per million. One of them is that condensed steam is capable of dissolving many materials in quantities sufficiently large to obscure the presence of the material it is desired to check. Another is that if ebullition occurs, dissolved solids may be carried away with the steam. In the apparatus designed in the laboratory the water is placed in a platinum bowl heated from above by a radiant heater to prevent ebullition, the whole being contained in a dust-tight enclosure, to which filtered air is supplied. As the water evaporates and the weight falls off, the bowl (which is mounted on a balance pan) rises, an electrical contact is made and more water is automatically added. The apparatus, which is illustrated in Fig. 8, will deal with about 5 litres of condensate in twenty-five hours.

Mechanical Testing

The mechanical testing section is equipped with all the usual machines for carrying out routine inspection and investigation into the physical properties of materials besides certain less usual ones, such as a machine for determining the modulus of elasticity of small metal specimens by the electronic measurement of resonant frequencies. The chief interest for the visitor lies in the equipment for testing samples of pipe and superheater tube material. Such samples are subjected to tensile stresses at elevated temperatures in electric furnaces such as those illustrated in Fig. 9. Since failure may not occur for some thousands of hours, there are seventy-two of these units in continuous operation. Superheater tubes are subjected to steam rupture tests in three machines—Fig. 10—each capable of containing six specimens. Steam pressures can reach 2000 lb. per square inch, and provision can be made to surround the tubes with flue gas atmospheres. Very high superheat temperatures necessitate the use of alloy steels of austenitic type; but, as is well known, difficulty may be experienced in service with the joints between these steels and ferritic or carbon steels, owing to different coefficients of expansion. Thermal fatigue tests are conducted on the machines illustrated in Fig. 11. The specimen consists of two pieces of ferritic metal with a piece of austenitic material welded between them. An enclosed heating element surrounds the bar, and at suitable intervals of time slides up and down so as to heat the two joints alternately. An air blast cools the unheated joint. The material is, of course, maintained under tension throughout.

Engineering Research

It is unfortunately impossible to refer to all the interesting work that we saw going forward in the engineering research section and the combustion research section; to the latter section

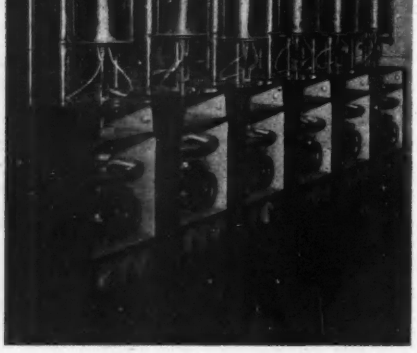


Fig. 9—Hot Rupture Testing Machines

Fig. 10—Steam Rupture Test Equipment

reference is made in the following paragraph. Eventually there will undoubtedly be published in the Press and before engineering institutions many informative papers about the researches now going on in these sections. Our account must be restricted to a very few items.

Reference has just been made to the testing of superheater tubes in the mechanical testing section. In the engineering research section an interesting, valuable and surprising discovery has been made. For years it has been assumed that the thinning of the metal upon the outside of the close radius bends used in superheater tubes must be a source of weakness. In fact, however, a large number of bursting tests, such as that illustrated in Fig. 12, has demonstrated that the close-radius bends are actually stronger than the straight tubes from which they are made. The explanation lies in the fact, demonstrable theoretically, that the maximum stress in a bend of uniform thickness occurs, not on

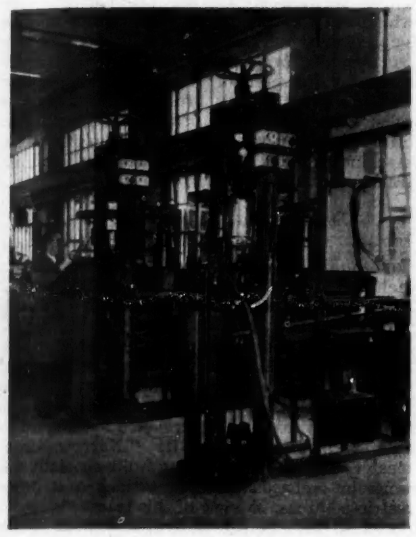


FIG. 11—THERMAL FATIGUE TESTING MACHINES

the outside, but on the inside. In a real bend thickening occurs here. Since it has previously been the practice to allow for the presumed weakness at the bends by using tubes of otherwise unnecessarily heavy gauge throughout a superheater, the discovery—presuming boiler inspection concerns can be convinced upon the point!—may lead to large savings of material.

Amongst equipment to which we gave special attention in this section was a dummy boiler drum rigged for steam separation testing. The drum has riser connections through which air and water can be pumped at velocities corresponding to those of the steam and water in an actual boiler, and producing thereby comparable turbulence in the drum. We noted, too, the attention being given to the task of expanding tubes into drums and headers. Increases in boiler pressures have led to a thickening of tubes, and of the walls of pressure vessels, and have made necessary a re-examination of the technique of making satisfactory expanded joints. Close study of the problem has led, as might be expected, to a greater understanding of the complex factors involved and to improvement in the tools and methods used in the process.

Combustion Research

In the combustion research section the visitor to the laboratories feels himself closer to actual practice than in any other department. For the direct relation between the work going on here and the operation of boilers in service is very obvious. Moreover, there are to be seen here, still in the development stage, devices that are obviously likely in the not distant future to become the normal practice of their day. The connection with actual practice is emphasised by the fact that this section works in close harmony with the staff operating the full-scale research boilers at the Renfrew works, already mentioned. There are many matters to which we could refer here. Interesting work is, for instance, going forward upon what may be termed the "burnability" of fuels, on the pilot scale by the use of combustion pot methods. Again, work carried out on the burning of so inferior a fuel as washery slurry encourages the hope that it can satisfactorily be used under boilers instead of costing some 2s. 6d. a ton to throw away! Developments in spreader stoker design are also of great interest. But perhaps the most interesting equipment seen was that

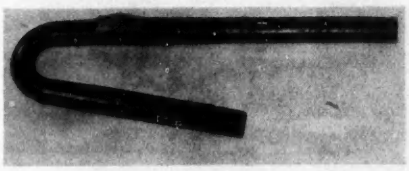


FIG. 12—SUPERHEATER TUBE TESTED TO FAILURE

to determine the combustion characteristics of solid fuel under pressure, so as to investigate the possibilities of pressurised boilers, and the various combinations of steam and gas turbo cycles. Small-scale tests are being made on unit combustion chambers, using air supplied by a 460 h.p. compressor. A larger plant incorporates a "Derwent" III jet engine fired by a slagging cyclone combustion chamber designed to burn about 1 ton of coal per hour.

Over at the Renfrew works there is being built a new 60,000 lb per hour boiler fired by a slagging cyclone. This plant will enable cyclone combustion tests to be carried out on British and foreign coals, and is expected to yield valuable information on the behaviour of the cyclone and its associated boiler.

Another activity of the section is the investigation of the difficult and intriguing problems arising out of the fouling and corrosion of heat-absorbing surfaces in boilers. For this purpose a number of test rigs has been set up. One of these rigs, consisting of a small furnace, brick-work passages to represent boiler passes, and a section of tubular air heater, is to be seen towards the left of Fig. 3, page 856, June 27th. Confirmation of research conclusions is sought by making observations at a number of large power stations in various parts of this country.

Metallurgical Section

A large part of the work of this section lies in routine examinations, and some parts of this work have been organised upon lines almost comparable with a mass-production factory. The section is also concerned with the investigation of service troubles. Amongst the many activities that can be ranked as research and development, those concerned with the behaviour of materials at elevated temperatures naturally predominate.

Full-Scale Boiler Equipment

Brief reference has already been made to the boiler plant available for experimental purposes at the Renfrew works. The 40,000 lb per hour high-pressure boiler is at present being used for the investigation of methods of spreader stoker firing. It is shortly to be fitted with new fans and feed pumps, capable of an output of 100,000 lb per hour, so that it will be possible to carry out tests at ratings considerably in advance of those in present use.

The 60,000 lb per hour unit, only installed this year, is fired by pulverised fuel and has been specially designed to facilitate experimental work on fuel mills. The set-up on the pulverising side is elaborate, and the boiler is designed for either direct firing or the bin and feeder system.

The Royal Show at Newton Abbot

No. II—*(Continued from page 866, June 27th)*

THE annual show of the Royal Agricultural Society of England opened at Stover Park, Newton Abbot, on Tuesday last, July 1st, and will close this evening, July 4th. The show ground, which covers 110 acres, is slightly smaller than those occupied by the "Royal" in recent years, but effective use has been made of a site which, owing to its somewhat irregular boundaries, has been by no means easy to plan. Visitors to the show are naturally disappointed that the cattle exhibits have had to be cancelled on account of the serious prevailing epidemic of foot-and-mouth disease; but the loss is admirably compensated at Stover Park by the excellent arrangements made by the Royal Agricultural Society for alternative exhibition items of outstanding interest. The machinery demonstrations and displays of historic implements are attracting considerable attention.

The machinery exhibits generally emphasise again the progress being made in this country in agricultural engineering. The results of the latest machinery census taken by the Ministry of Agriculture show that in the last two years there have been further substantial additions to the mechanical equipment of British farms, particularly in machines for root and grain harvesting. A tour of this year's Royal Show indicates that as well as numerical increases in farm machinery, there is continual improvement in design, and that there is also a readiness on the part of British agricultural machinery makers to extend their export activities.

We continue, in what follows, illustrated descriptions of some of the implements and machines exhibited.

Catchpole Engineering Company, Ltd.

For some years past the Catchpole Engineering Company, Ltd., Bury St. Edmunds, Suffolk, has been engaged in the development and production of machinery for the complete mechanisation of sugar-beet harvesting. This year it is showing at Newton Abbot a new beet top saver, which is illustrated in Fig. 7. The machine is tractor-drawn but is driven from its land-wheels. The complete unit is built around a rectangular, tubular chassis mounted on two 30in diameter steel wheels, which are movable to suit row widths. The drawbar being adjustable in height to suit any tractor. The seat for the operator enables a clear view of the picker unit and beet row and the machine is steered by a tiller connected

FIG. 7—BEET TOP SAVER—CATCHPOLE

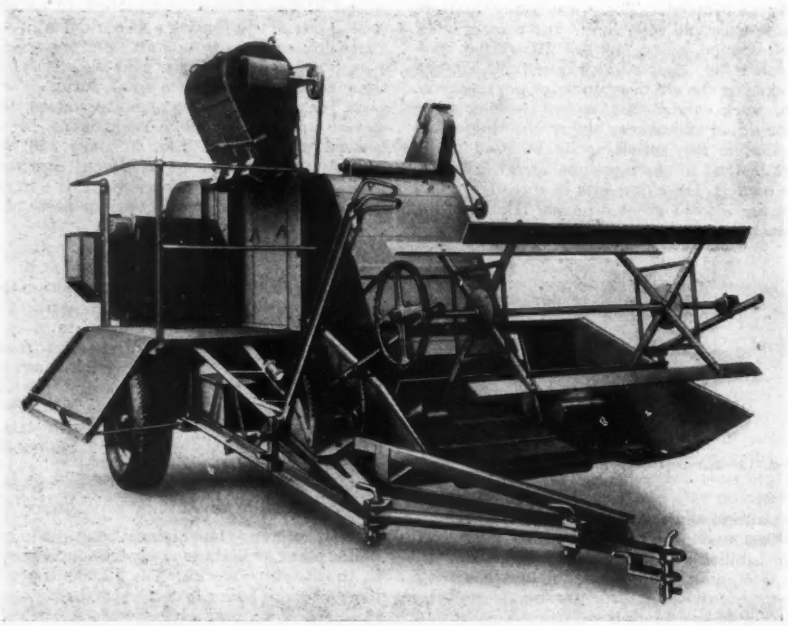


FIG. 8—ENGINE-DRIVEN COMBINE-HARVESTER—MARSHALL

to a hinge joint in the drawbar. The picker unit, consisting of four 3ft diameter steel discs having saw-like teeth around the periphery, is mounted on a hub having roller bearings and oil seals, running on a short shaft. This unit is driven by chain and sprockets from the live road-wheel axle at a speed equal to the forward progress of the machine. A pair of topping discs, 14in in diameter, are mounted at the ends of two caliper arms arranged to straddle the picker unit. These arms are spring-loaded to allow the passing of large stones or other obstructions. The severed crowns and tops of the beet are impaled on the picker unit, carried round three-quarters of a turn and transferred to a chain elevator by the stripper wheels, which are arranged to comb the tops off the picker wheels by rotating at a higher speed and in the same direction. The elevator, to which a windrowing attachment can be fitted, is driven by vee belting from the stripper wheel shaft. A pair of concave discs fitted in front of the picker unit, turn away broken beet leaves and similar trash. The picker unit can be lifted clear of the ground for travelling by a hand lever, which is placed conveniently near to the operator, and ratchet hubs are provided in the road wheels to facilitate turning. The pawls may be totally withdrawn when the machine has to be towed some distances, thus disengaging the drive.

MARSHALL, SONS AND CO., LTD.

The stand of Marshall, Sons and Co., Ltd., Gainsborough, is shared, as usual, by its associate, John Fowler and Co. (Leeds), Ltd. There is shown the wheeled and track tractors produced by both companies, including the Fowler "Challenger I" diesel crawler tractor, which was described and illustrated in THE ENGINEER of November 30, 1951. The tractor is powered by a Marshall vertical twin-cylinder, two-stroke diesel engine developing 50 b.h.p. at 1250 r.p.m. The change-speed gearbox has six forward speeds between 1·68 m.p.h. and 7·2 m.p.h. and two reverse speeds of 1·27 m.p.h. and 2·96 m.p.h. An earlier "Challenger" tractor, which will also be exhibited, is that powered by a Meadows or Leyland six-cylinder, four-stroke diesel engine, developing 95 b.h.p. at 1550 r.p.m.

For the first time the Marshall "626" combine-harvester, is being shown (Fig. 8). This harvester is a tractor-drawn machine, which has a cutting width of 6ft and a threshing drum intake width of 3ft. Power for the harvester is provided by a Ford industrial petrol engine developing 20 b.h.p. at a governed speed of 2250 r.p.m. Although the harvester has a somewhat narrower cut than is usual, the makers claim that it is compensated for by the fact that the machine can be towed at a faster working speed. The header and cutter-bar are spring-mounted—to prevent damage from "ploughing-in"—and are adjustable to cut from 2in to 20in. Twin half-augers deliver the cut crop to a 3ft-wide canvas conveyor and an endless chain-driven elevator, and from there the crop is fed, by the front beater and stripper, to the threshing drum, which is 18in in diameter and has eight ribbed beater bars. The normal speed of the drum is 1320 r.p.m. A four-vane beater strips the straw from the drum and directs it to four box shakers reciprocating on double cranks. The grain is fed to a set of five dressing riddles with perforations $^{3}/_{32}$in, $\frac{3}{16}$in, $\frac{5}{16}$in, $\frac{7}{16}$in and $\frac{9}{16}$in, and is taken by an elevator, fitted with rubberised balata scrapers, to an adjustable rotary grading screen, which is equipped with a spring-loaded brush. Three bagging spouts are provided, two of which are for best quality grain and one for small grain and dust, and the area of the bagging platform allows the operator ample room for full control of the harvester. The two travelling wheels are mounted on taper roller bearings and are fitted with 8in by 19in heavy service tyres. The overall length of the machine is 22ft, its height 9ft 5in, and its transport width 9ft 6in.

DAVID BROWN TRACTORS, LTD.

Examples of the wheeled and track tractors now built by David Brown Tractors, Ltd., Meltham, Huddersfield, exhibited, include a new version of the "Cropmaster" diesel, which is fitted with a four-cylinder direct-injection, cold-starting diesel engine giving 34 b.h.p. at 1800 r.p.m. The new tractor, like other versions of the "Cropmaster," has a twin-range three-speed gearbox, which provides for six forward and two reverse speeds. The firm is also exhibiting its "Narrow Cropmaster," which is now being built specially for work in orchards and plantations and other restricted areas. A view of this tractor is reproduced in Fig. 9. It is available with either kerosene, petrol, or diesel engines with four cylinders, $3\frac{1}{2}$in bore by 4in stroke, the kerosene engine output being stated as 35 b.h.p. at 2000 r.p.m. In general, the specification of this tractor differs little from that of the "Cropmaster" series, but reduction of the track width has been effected by fitting special reduction housings—with no protruding locknuts—to the rear axle. Two sizes of rim and tyre are available, the minimum track width being 3ft $7\frac{3}{4}$in, giving an overall tractor width of 4ft $5\frac{1}{2}$in on 9·00 by 28 pneumatic tyres. A fabricated steel front axle of new design decreases the front track width and gives extra ground clearance up to 16in. It will be noted from the illustration that the usual vertical exhaust has been eliminated; instead a downswept pipe has been

FIG. 9—NARROW "CROPMASTER" TRACTOR—DAVID BROWN

FIG. 10—ALTERNATING ONE-WAY PLOUGH—DAVID BROWN

fitted, giving a smooth bonnet surface which will not foul low-hanging branches. The tractor has a turning radius of 13ft 3in. The makers' standard hydraulic lift has been incorporated in the design, and, if desired, a two-speed power take-off can be fitted for operating sprayers or irrigation pumps.

More than sixty different implements are now being manufactured for work with David Brown tractors. Among the latest of them is the "Pamcol" alternating one-way plough, illustrated in Fig. 10, which is being shown at Newton Abbot for the first time. It is a single-furrow implement, the reversing action being controlled by a handle conveniently operated by the tractor driver. On operating the reversing handle, a gravity pawl engages with a ratchet wheel, which, through its spindle, rotates a crank. This, in turn, actuates an adjustable connecting-rod, and, through steel quadrant gears, the rocking arm is pivoted about its axles. A latch which engages with the ratchet wheel ensures that the mouldboards of the plough are locked in their working positions. Fully adjustable coulter discs are provided and the skims can also be adjusted according to the working depth. A single pressed steel depth control wheel suffices for both plough bodies. The design of the plough provides for three kinds of interchangeable body—12in. semi-digger, 14in continental, and 16in deep digger. Another new implement on this stand is the "Teasdale" folding harrow, which has a working width of 12ft and can be folded for transport to 7ft 9in.

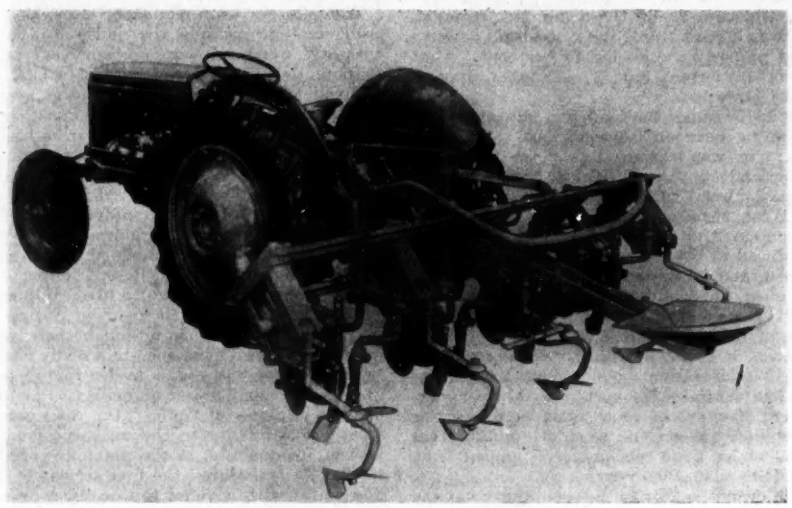


FIG. 11—GANG STEERAGE HOE—FERGUSON

HARRY FERGUSON, LTD.

A new implement, which was entered for the Royal Agricultural Society's silver medal award, is the mounted gang steerage hoe made by Harry Ferguson, Ltd., Coventry. One of the problems associated with mechanical row crop hoeing is to ensure that each hoe, or gang of hoes, penetrates the ground to a uniform depth. In the Ferguson gang steerage hoe, illustrated in Fig. 11, use is made of a hydraulic mechanism to ensure that each hoe gang follows the ground contour independently. The implement deals with four rows at a time and thus requires five hoe gangs, each of which is attached to a tool bar by a parallel linkage, balanced in all positions by a tension spring and cam arrangement. This linkage is so designed that ground reaction is the only controlling force upon the hoe gangs. When the implement is at work, any variation in ground contour will cause a hoe gang to rise; a hydraulic system of cylinders and pistons thereupon applies a proportionate thrust against the tractor control spring, thus raising the implement as a whole. At the same time, the remaining hoe gangs receive—through a hydraulic system which is an integral part of that just mentioned—a proportional thrust in a downward direction, and thereby maintain their working depth. The volume of fluid in the implement's main hydraulic system remains constant. The fluid displaced when one gang rises flows equally into the other gang cylinders and so produces the proportionate downward movement. The implement has all the conventional equipment of a steerage hoe, the row width being variable from 16in to 24in in 1in steps.

There are many other implements for operation with Ferguson tractors displayed on the firm's stand. They include a "corn and cotton" precision seeder, which will place single seeds at predetermined intervals from 1in to 36in, and a high-lift cantilever loader, with a lifting capacity of 10 cwt, the discharge height for the fork attachment being 11ft. The five classes of Ferguson tractor are also shown. One of the more recent additions here is the vineyard tractor, which, with an overall width of 3ft 10in is 18in narrower than the firm's standard tractor. Although in this tractor both the rear and front axles have been shortened, the steering geometry is not affected, and to obtain the necessary clearance for the cross swinging of the front axle the radiator has been moved 3¾in forward. With smaller wheels, both front and rear, the overall height has been reduced, compared with the standard tractor. Extra front wheel weights are provided to improve the stability of the tractor when working with long overhung implements.

THE GENERAL ELECTRIC COMPANY, LTD.

The application of electricity to agriculture and horticulture is demonstrated by the exhibits of the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. The equipment shown includes sterilising and water heating plant for dairy use, and a horticultural plant illuminator, the purpose of which is to accelerate the development of seedlings.

An important exhibit on this company's stand is the platform "in-sack" grain drying installation. The increasing use of combine harvesters in this country has emphasised the importance of grain drying and throughout the Show there may be seen examples of the various drying systems which have been developed by British firms. One of the systems for which the G.E.C. supplies the necessary equipment is the platform or "in-sack" drying method. The National Institute of Agricultural Engineering has investigated this method of grain drying and has found that with a given volume of air about 25 deg. Fah. above atmospheric temperature the drying rate is approximately 1 per cent moisture content reduction an hour. The equipment consists of a sack platform made of concrete slabs supported about 18in above ground level to form an air chamber. The top of this platform incorporates apertures with gratings on which the sacks of grain are placed. The warm air for the drying process is provided by an "Aerofoil" fan and duct air heater, which can be arranged either for straight entry, right angle bend entry or vertical entry. In Fig. 12 there is reproduced a typical fan and heater battery installed parallel with the sack platform. The capacity of the fan and heater battery is naturally dependent upon the size of the complete plant,

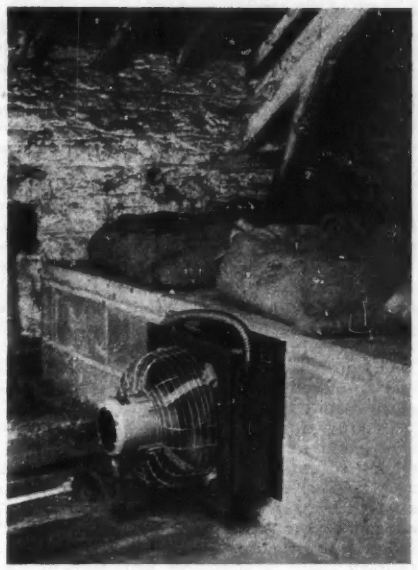


FIG. 12—"IN-SACK" GRAIN DRYING—G.E.C.

but for a twenty sack drying platform the requirement is a 1 h.p. single-stage fan, 15in diameter, and turning at 2850 r.p.m. The air heater is a 25kW, 18in square duct, with the load divided into three sections. This equipment is suitable for a 400/440V, three-phase, 50 c/s supply. The fans for use with these grain drying equipments are made by Woods of Colchester, Ltd., one of the G.E.C.'s associated firms.

(To be continued)

The Belver Hydro-Electric Scheme, Portugal

CONTINUING the policy of increasing the the hydro-electric development of the country, the Portuguese authorities recently opened the Belver scheme on the Tagus. The scheme was erected by the Hidro-Electrica Alto Alentejo of Lisbon: it includes a dam, designed by the Swiss Professor Dr. A. Stucky, which is situated about 105 miles from the mouth of the Tagus; it consists of three sections: a gravity dam 370ft long, including a lock of 229ft by 36ft; a movable dam 967ft long, consisting of twelve sluiceways and thirteen piers, the openings being closed by twelve double gates measuring 56ft in length and 46ft in height; and the power house with four vertical Kaplan turbo alternator sets, having a total capacity of 44,000 h.p. The overall length of the barrage is about 1500ft, while the gates are amongst the largest in Europe.

Extensive scale model tests were carried out in the laboratory of the Lausanne Polytechnic School in order to determine the shape and the size of the piers. These piers are founded on the rock at a level generally 17ft below the river bed. The volume of the excavation work amounted to some 170,000 cubic yards; about 120,000 cubic yards of concrete were placed on the contract. The civil engineering works started in 1948 and were completed in 1950; the gates were placed in position in 1951. Two sets of turbines were installed in 1951 and two others in April, 1952.

The End of London's Tramways

LONDON'S remaining trams will be withdrawn from service on the night of July 5th-6th, when the final stage of the scheme for converting South London's tramways to bus operation will be completed. This change marks the end of an era in the transport history of the capital.

It was in March, 1861, that George Francis Train, an American, opened his Marble Arch Street Railway with a horse-drawn single-deck tramcar along the Bayswater Road between the Marble Arch and Porchester Terrace, a method of transport which he had introduced this side of the Atlantic in the previous year at Birkenhead.

Stimulated by the apparent success of his venture, Train also opened the Westminster Street Railway along Victoria Street and the Surrey Side Street Railway from Westminster Bridge to Kennington. Train felt that few Londoners could afford a carriage, the horse-buses of the day were uncomfortable and their conductors uncivil. He therefore counted on support from the millions who could have "at his expense" the use of a pair of greys and an elegant carriage large enough for their entire family for twopence each. "I cannot," he said, "think that anyone would wish to throw any impediment in the way of introducing so great a luxury as the people's carriage." But the rails he had laid protruded above the roadway, to the justifiable annoyance of other road-users, and soon he was ordered to remove them. His Birkenhead tramway and another he had laid in the Potteries were saved from extinction only by the timely substitution of flat grooved rails for the original "step" rails.

London's roads were comparatively good and horse-buses and horse-cabs plentiful so the need for tramways appeared less urgent in the capital than elsewhere; their advocates therefore retired temporarily into the background. In 1868, however, an Act of Parliament was passed which authorised a passenger tramway in Liverpool and the next year sanction was given for the following in London: the Metropolitan Street Tramway from Westminster Bridge to Kennington, Brixton and Clapham; the Pimlico, Peckham and Greenwich Tramway from Greenwich to Vauxhall, and the North Metropolitan Tramway along the Whitechapel, Mile End and Bow Road. All came into operation in 1870; the first two amalgamated almost immediately as the London Tramways Company, a title similar to that of another pioneer, the London Street Tramways Company, which entered the field in 1871 with lines in Holloway and Kentish Town.

The passing of the Tramways Act of 1870, which amongst other things empowered local authorities to arrange for the working of tramways in their areas with an option to purchase after twenty-one years, led to a spate of new schemes. Within six years, sixty-one miles were opened and plans were prepared for others in districts as dissimilar as Piccadilly and Regent Street on the one hand and the City's narrow streets on the other. In the wealthier districts, however, the local authorities' power of veto under the 1870 Act was invariably exercised. Trams, therefore, never ran in the west end of London; Train's ill-fated Marble Arch venture was an exception and may be regarded as a mark of his supreme optimism, for it is unlikely that the residents of Bayswater looked upon it as anything but a novelty. In the City, initially because of pressure by the police authorities, the Corporation withheld approval to tramways penetrating their boundaries for many years.

Economists of the period no doubt realised—if enthusiastic promoters did not—that tramways, with their inflexibility and heavy capital costs, could operate with economic advantage only where reasonably heavy traffic was both immediately available and assured for years to come. In predominantly working-class districts, therefore, the horse-tram soon became firmly established and can be said to have developed cheek by jowl with the horse-bus. Each, of course, had its adherents; the railed vehicle gave a smoother ride in those days before the advent of the pneumatic tyre and also—an important innovation—provided early-morning journeys, but perhaps partly because of this very fact, or because parcels could be carried on its commodious platforms, or even because it had been dubbed "the people's carriage," tram travel was regarded by many as undignified. In one district at least, however, the coming of the tram has gone on record as a good thing, for it was said to have raised property values by 40 per cent. That was in Battersea, but it no doubt applied equally elsewhere.

In 1876 came the western suburbs' first tramway, between Acton and Shepherds Bush; it was operated by the Southall, Ealing and Shepherds Bush Tram-Railway Company but later it was taken over by the West Metropolitan company, forerunner of London United Tramways. Trams were introduced in Croydon in 1879, in Bermondsey in 1880, and in the northern suburbs in 1881. The most important of the pioneers was the North Metropolitan company. From its 9½ miles of line (over which in the first year of operation it ran ¾ million car miles and took £44,000 in fares from some 5 million passengers) they had extended the system within six years to over 30 miles of routes and were carrying 27 million passengers over 3¼ million car miles, whilst their receipts had jumped from £44,000 to £230,000 a year.

But even the North Metropolitan company had to look to an omnibus company to supply and maintain their horses. For this they paid the London General Omnibus Company 6¾d. per car mile; when it is realised that each tramcar needed a stud of eleven horses and that the average life (that is, working life) of a tram horse was only four years, it is not surprising that, from the start, a method of traction other than by horse-power was being sought by the tramway promoters. The first attempts at mechanical power were in the nature of tractors; in 1871 Loftus Perkins patented his so-called steam "tram-horse," tried out a little later and followed by a trial run of John Grantham's steam-operated tramcar, whilst 1877 saw experiments with compressed air tractors. The Government was by now being urged to legalise the use of mechanical power and in that year a Select Committee of the House of Commons reported favourably on the matter.

During the next few years various experiments were conducted with battery locomotives, until, in 1883, came the first self-contained electric tramcar, a battery-operated horse-car, operated for one day only by the West Metropolitan company. In the following year Clifton Robinson inaugurated his steam-operated cable tramway on Highgate Hill; it was the first in Europe, and was followed by another on Brixton Hill. In addition to these cable cars, the late 1880s saw regular services running with three different kinds of mechanically-propelled tramcars (to the exclusion of horse-drawn cars), namely, steam and compressed-air in North London and electric battery cars along the Barking Road. The latter ran for as long as three years.

By 1891 so many companies controlled London's tramways that the newly-created London County Council decided to achieve co-ordination within their area by exercising purchasing powers under the 1870 Act. Powers to operate tramways were granted to the Council in 1896 and by 1909 it had bought up 113 miles of tramway, half north and half south of the Thames, or practically all the lines within the county, including the major part of the systems of two of the 1870 pioneers—London Tramways and North Met.—as well as those of ten other companies and a local authority.

With the turn of the century came London's first regular electric tram service with an independent power supply. In this respect the capital lagged behind the rest of the country, although the comment of a newspaper of 1899 that "these smooth, gliding horseless cars are to be seen almost everywhere but in London" was somewhat exaggerated. In 1900 the London County Council had obtained powers to electrify but the honour of having the first service in operation fell to London United Tramways, whose electric system, designed and constructed by Clifton Robinson (whose taste for tramways doubtless began with his experience as office boy to Train forty years earlier), opened in April, 1901, two years or so before the first London County Council route.

The electric tram certainly brought fresh problems—for example, the choice of installing unsightly overhead wires, expensive conduits or potentially dangerous contact studs, was resolved largely by adopting conduit systems for the inner districts and overhead wires elsewhere. In return the electric tram brought to built-up areas smooth, speedy and convenient travel. Within five years it was not only established but considered indispensable. Even the advent of the motor-bus did little to shake the confidence of tramway protagonists who were, if anything, inclined to be somewhat patronising about it. A letter from Clifton Robinson (now Sir J. Clifton Robinson), printed in the *Times Engineering Supplement* in 1905, suggested that although there was a wide field of usefulness open to a really efficient type of motor-bus,—as a feeder to the tramways!—for rapid transit and effective handling of large volumes of traffic "the road carriage must prove inferior to the railborne vehicle." It was, incidentally, in the previous year that the L.C.C. introduced the first service of London trams with covered top decks, a development which took another twenty years to reach the bus.

From 1903 onwards the London County Council electrified most of its tramways, as well as extending them, and by 1915 when their last horse-tram was withdrawn, the Council had no fewer than 144½ route miles of electric tramway in operation. During this period, however, other operators had by no means stood still. Outside the county, two privately controlled companies (London United and Metropolitan Electric) conducted operations in Middlesex; elsewhere in Greater London tramways were mainly in the hands of the local authorities. Steady expansion by the two companies mentioned brought their systems jointly to well over 100 miles, whilst most of the smaller undertakings extended their operations with through services over one another's metals, a practice in which the L.C.C. joined in 1910.

The London County Council had already linked the hitherto quite separate systems north and south of the Thames by completing the Kingsway Tram Subway and inaugurating, in 1908, through-services from Highbury to Tower Bridge or Kennington by way of Westminster Bridge. It is remarkable that for nearly half-a-century no trams crossed the river—in fact, the mere reaching of the river by South London tramways was regarded as an occasion. The laying of tracks over Westminster Bridge in 1906 led to development of the wide Victoria Embankment as a terminal, whilst the crossing of Blackfriars Bridge three years later made possible the loop working over the two bridges, which has remained in use until to-day.

But the once insignificant motor-bus was becoming a competitor. The main cause of the decline of the tram was undoubtedly the improvement of the internal combustion engine, for it gave to public transport flexibility as well as speed. The motor bus, object of ridicule of the early 1900s, developed rapidly and brought about, in as little as a generation, the dislodgment of the electric tram from the pre-eminent position in which it had seemed so secure. Whilst in 1911 trams carried two-

thirds of Greater London's passengers, ten years later the proportion was down to half, and by 1927 had dropped almost to a third—despite an ever-increasing number of passengers. A glance through the tramway returns of the 1920s might have occasioned no alarm, but to those in possession of all the facts the writing on the wall must have been apparent. In 1920 the L.C.C. tramways, after a quarter of a century's operation, incurred their first deficit and only four years later the Council were exploring the possibilities of future development by way of "the rail-less tram and omnibus rather than the fixed-track tramway."

In 1931 an attempt was made to regain lost ground with the introduction by the London United and Metropolitan Electric companies, of a radically improved tramcar, but the former company's introduction in the same year of London's first trolleybus route implied that the tramcar was already outmoded. The laying of London's 700 miles of tramway had cost £10 million, but after 1932 no new trams were built to run on them. In 1933 came the transfer to the London Passenger Transport Board of the 2600 cars and 327 route-miles of the capital's seventeen tramway undertakings, including the L.C.C.'s 1713 cars and 167 miles of route.

The London Passenger Transport Board decided to abandon tramway working in favour of trolleybuses and, by 1940, all routes north of the Thames, except for a few miles, had been replaced by trolleybus routes. The war caused postponement of the remainder of the programme, but, meanwhile, the balance as between the trolleybus and the oil-engined bus had changed and it was decided to replace the remaining trams by oil-engined buses. The conversion scheme was planned in nine stages, starting in October, 1950, but has been completed in eight.

During its ninety-one-year span the tram has played a great part in providing rapid and economical travel for Londoners. It has, however, also played a great part in adding to the ever-growing congestion of the London streets and the following quotation from *The Times* would appear to provide a fitting conclusion to this necessarily brief account: "It is now admitted on all sides that it has been a huge mistake to construct tramways in certain districts in which narrow streets abound. Not only is the prime cost stupendous but, when laid, the tram proves a gigantic nuisance. It blocks the very traffic which it ought to relieve." That was written, not in 1952, but as long ago as 1905!

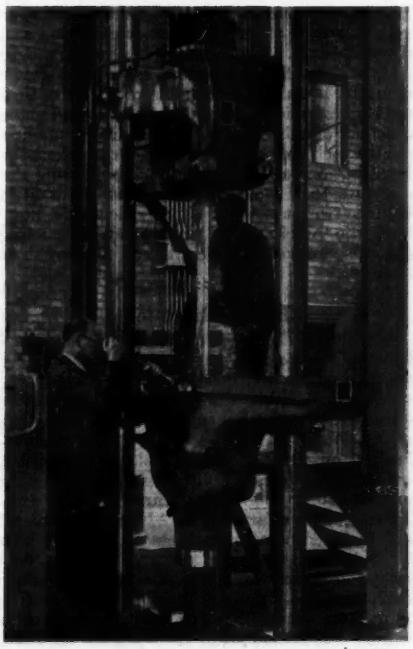
For the purpose of record, the services to be withdrawn are those between Abbey Wood and Victoria Embankment, Plumstead (Wickham Lane) and Victoria Embankment, and those between Woolwich (Beresford Square) and Eltham Green, City (Southwark) and Victoria Embankment (Savoy Street).

ECONOMY IN LOCAL GOVERNMENT SERVICES.—The Minister of Housing and Local Government, Mr. Harold MacMillan, has sent a circular to local authorities and water and sewerage undertakings calling their attention to the need for economy in local as well as national government. To relieve demands on labour and materials Mr. MacMillan has asked local authorities to delay or postpone schemes which, though desirable, are not urgent or essential to their vital needs. In the case of works designed for public health, for instance, he states that claims must be supported by a report from the medical officer of health. In schemes of rural water supply, priority will be given to those for areas where there is no piped water at all. Attention is drawn to the importance of new or improved measures for the prevention of waste of water as a means of obviating the necessity for new works. Some curtailment of expenditure on private street works will be unavoidable, it is stated, and coast protection schemes which require substantial amounts of steel will also have to be deferred or slowed down. In general, local authorities are asked to concentrate capital works on those schemes whose deferment, even for a short period, would endanger life or health or are otherwise in the highest degree essential.

A Fatigue Testing Machine at the B.W.R.A. Laboratory

AMONGST the new items of equipment which we saw during the opening of the new laboratory of the British Welding Research Association, as reported in a journal note last week, was a 100/200 ton Losenhausen universal testing machine, which apart from static loads is capable of applying dynamic loads under pulsating tension, compression or alternating conditions. With this machine, which we illustrate herewith, fatigue tests can thus be carried out with loading conditions not possible with the resonance vibration methods to which work had previously been confined.

The Losenhausen machine is one of the largest fatigue testing machines in the country. It has a maximum dynamic range of 100 tons load, which can be applied within any two limits which do not exceed 100 tons tension or 100 tons compression, e.g., +75 to −25 tons, ±50 tons, +20 to −80 tons. The machine is also suitable for carrying out static tensile, compression, buckling and bending tests up to a maximum load of 200 tons. Axially loaded test pieces up to 6ft clear length can be accommodated and bending tests can be carried out on specimens between 1½ft and 6½ft in length and up to 18in in width. The maximum extension which can be applied to specimens is 0·2in and 6in for dynamic and static conditions, respectively. The machine is operated hydraulically and a simplified diagram of the mair hydraulic circuit is reproduced above. High pressure fluid is led from the pump and communicates with the pulsating cylinder, and with the top or tensile cylinder.



ADJUSTING SPECIMEN IN LOSENHAUSEN MACHINE

With the plunger in the position shown, the desired maximum tensile load is communicated from the pump to the tensile cylinder. The piston at that position is at its top dead centre and it is caused to reciprocate by the rotary crankpin through the agency of the oscillating arm which does not rise above the horizontal. The stroke of this piston can be adjusted to suit the required minimum tensile load obtained when the plunger is displaced towards its bottom dead centre. This adjustment is achieved by displacing the fulcrum of the oscillating arm horizontally. In this way, having adjusted the crank to the cyclical speed, it would be theoretically possible to obtain alternating load cycles from 0 to the maximum of 100 tons.

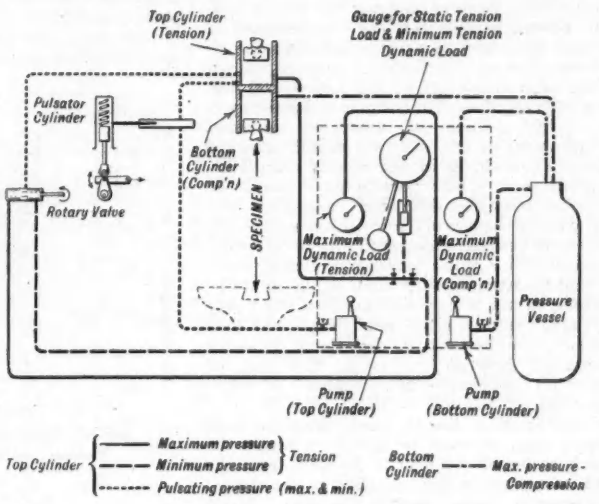


DIAGRAM OF MAIN HYDRAULIC CIRCUITS

However, for reasons associated with the dynamics of the pendulum manometer, it is necessary to adjust the pulsating cylinder so that the lower limit does not drop below 10 tons tension. To obtain zero loading in the tensile range, therefore, the oil pressure vessel which communicates with the bottom section of the composite cylinder is opened to admit a load of 10 tons compression, which consequently neutralises the residual tensile load. It is obvious also that the maximum tensile load applied must also be restored by the amount of the compression load applied. Thus, in a cycle requiring maximum and minimum loads of ±50 tons, respectively, the pulsating cylinder would be adjusted to exert 110 tons tension in the position shown (top dead centre) and allowed its maximum displacement whilst a load of 60 tons compression would be exerted upon the bottom half of the cylinder from the pressure vessel.

The rotary valve which is connected to the rotating crank makes one revolution per cycle and enables the maximum and minimum tensile loads to be registered, the latter load being measured by a pendulum manometer, which also serves as the gauge for static tensile loads. The method of applying static loads is apparent from the diagram. The mounting of this machine at Abingdon differs from the normal method in that the bed is supported on four clusters of leaf springs on end and loaded almost up to the Euler limit.

ELECTROMAGNETIC FLAW DETECTION.—The Manchester Oil Refinery, Ltd., has issued a leaflet "Supramor," an electromagnetic flaw detection ink, for the detection of cracks caused by stress, fatigue and heat treatme nt, &c., also forging flaws, and blowholes in castings.

Metallurgical Topics

Intergranular Corrosion of Stainless Steels

AUSTENITIC stainless steels of the 18 : 8 chromium-nickel type are subject to intercrystalline corrosion or weld decay after being heated within the range 500 deg. to 800 deg. Cent. or after being welded. Although intercrystalline attack is more rarely observed after the welding of steels containing less than 0·07 per cent of carbon, long heating within the range of temperature mentioned above may induce subsequent intercrystalline corrosion even when the carbon content of the steel is much lower. Besides reducing the carbon content, special carbide formers like titanium or niobium are added as a further precaution.

Some years ago the tendency to intergranular attack after treatment at 500 deg. to 800 deg. Cent. was attributed to chromium deficiency in the neighbourhood of separated carbides. Intergranular attack is, however, still observed in steels containing 24 per cent of chromium, and with such a high percentage it cannot be supposed that the deficiency caused by precipitation of carbide in a low-carbon steel would be sufficient to lead to susceptibility to corrosion. Moreover, austenitic chromium-nickel steels containing titanium are susceptible to intergranular attack if they are quenched from very high temperatures (1250 deg. Cent.) and then heated at 600 deg. to 700 deg. Cent. It seems necessary, therefore, to revise this idea of chromium deficiency as a cause of intercrystalline corrosion.

High-chromium ferritic steels also show weld decay; but, whereas in austenitic steels the attack occurs at some little distance from the weld, at a position corresponding to the critical temperature zone during welding, intercrystalline corrosion of ferritic steels takes place close to the weld seam. It is not necessarily a supplementary annealing at a lower temperature which causes susceptibility in high-chromium ferritic steels; the mere exposure to the high temperature with subsequent cooling provides the conditions which lead to intercrystalline attack. Though these steels, also, are stabilised by carbide-forming elements, the question remains as to why there should be the difference in position of the temperature zones, exposure to which confers susceptibility to intergranular corrosion. Experiments described by E. Houdremont and W. Tofaute* throw some light on this question.

These authors studied the influence of hardness and microstructure on the susceptibility to intercrystalline corrosion of ferritic and martensitic chromium steels containing 15 to 30 per cent of chromium with or without additions of molybdenum, silicon, aluminium, phosphorus, titanium, tantalum, niobium, and vanadium. The steels, in the form of 2mm to 6mm thick plates, were heated at temperatures of 700 deg. to 1350 deg. Cent., quenched in water or cooled in air, and their susceptibility tested by treatment in the usual copper sulphate-sulphuric acid solution. In 17 per cent chromium steel, cooling by either method from 950 deg. Cent. or above gave susceptibility to intergranular attack. Investigations of the susceptibility of martensitic steels to grain-boundary corrosion show that carbide precipitation is the cause. Martensitic steels with 0·2 per cent to 0·4 per cent carbon, chromium 14 per cent to 19 per cent and up to 2 per cent of nickel, when heated at 1000° deg. Cent. or over, fall almost completely in the γ or $\alpha+\gamma$ field, and on quenching consist of a carbon-poor, chromium-rich martensite, and a carbon-rich chromium-poor austenite, which on cooling to room temperature deposits carbide on account of its high degree of supersaturation in carbon. Magnetic tests show that susceptibility to intergranular corrosion is greatest in steels containing the non-magnetic austenite, and especially after reheating at 300 deg. or 400 deg. Cent. after quenching from 1300 deg. Cent. (Fig. 1). This treatment precipitates the carbide without decomposing the austenite. When the reheating temperature is high enough to decompose the austenite, the tendency to intergranular corrosion disappears. In low-carbon steels with 17 per cent to 24 per cent of chromium, which, in the absence of nickel, are ferritic right up to the melting point, and show susceptibility to intergranular attack after being cooled from temperatures above 950 deg. Cent., complete stability is only attained if the steels are decarburised and denitrogenised in hydrogen before quenching. Addition of titanium inhibits intergranular attack in ferritic steels, but the titanium must be present in larger amounts than in austenitic steels. Niobium and tantalum act similarly, but vanadium and molybdenum are ineffective, and so also are such elements as

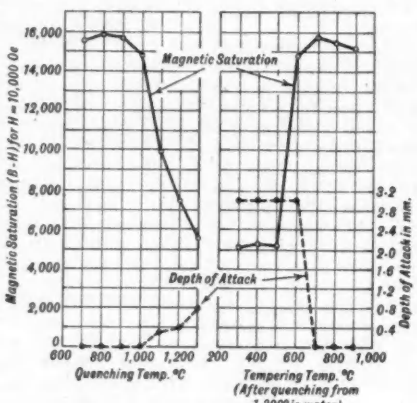


FIG. 1—*Magnetic Saturation and Depth of Intergranular Attack of Quenched and Tempered Steel Containing Carbon 0·2 Per Cent, Chromium 18 Per Cent, and Nickel 1·8 Per Cent (Cooled in Water from the Quenching and Tempering Temperatures)*

silicon, aluminium and phosphorus. Steels with 10 per cent to 30 per cent of chromium and low carbon fall within an alpha+carbide region at room temperature: and the carbide which is precipitated during cooling is given as $(Cr, Fe)_4C$, in accordance with the diagram of Tofaute, Küttner and Büttinghaus,† but is more accurately $(Cr, Fe)_{23}C_6$. As first deposited it is poor in chromium, and the presence of this easily attacked carbide is considered by Houdremont and Tofaute to be responsible for the occurrence of grain-boundary corrosion and of weld decay. This opinion is already widely held, and A. B. Kinzel,‡ in his recent Howe Memorial Lecture, has demonstrated by optical and electron micrographs the presence and mode of attack of this carbide. In welding austenitic steels, which are non-susceptible as quenched, the precipitation takes place only on reheating the austenite to a temperature reached at a little distance from the weld. In ferritic steels, however, the precipitation occurs during cooling and the immediate vicinity of the weld is affected.

Electrothermics

IN this jubilee year of the Electrochemical Society, the *Journal* contains reviews of fifty years' progress in those branches of industry which come within the range of the Society's activities. In the February number an article by Mr. W. Blum (of the U.S. Bureau of Standards), on fifty years of electrodeposition, reviewed progress in electro-refining, plating and electroforming. The March number contained a series of articles on "Electrothermics" or "high-temperature processes involving heat derived from electrical energy." They deal with the industrial products of the electric furnace. The application of electric heating to metallurgical and chemical processes on a commercial scale began as recently as 1890, though laboratory and small-scale experiments of Moissan, Siemens, Héroult and others are of earlier date.

CARBON AND GRAPHITE ELECTRODES

The importance of carbon electrodes in electrical development was evident from the time of Sir Humphrey Davy, who made a spark jump between two rods of wood charcoal in 1800. Foucalt replaced this by gas carbon, which was harder, a better conductor and did not waste so rapidly. The importance of carbon electrodes increased with the introduction of the Héroult furnace about 1886, and in later years carbon electrodes were usually prepared artificially. In 1897, E. G. Acheson built the first graphitising furnace, and in 1900 the International Acheson Graphite Company was formed. The first electrolytically produced aluminium was put on the market in 1890 and to the aluminium industry belongs the credit of speeding up the development of carbon electrodes. With the experience of the aluminium industry to draw upon, the electric-furnace steel industry was firmly established during the years 1900 to 1910 and showed rapid expansion during the 1914–18 war. The development of carbon and graphite electrodes is reviewed by C. G. Ollinger.† Artificially prepared graphite has given rise to a multitude of products ranging from small, finely machined mechanical and electrical parts, through porous and impervious grades to massive blocks for furnace linings.

ABRASIVES AND REFRACTORIES

One of the first materials to be commercially manufactured in the electric furnace was silicon carbide (carborundum). The method of its production has remained much the same as it was when introduced by E. G. Acheson over sixty years ago. G. M. Butler† states in his article that, though originally used as an abrasive, about half the carborundum now produced is used for high-temperature electrical heating and as a refractory in kilns and furnaces. Other materials made in the electric furnace and serving both as abrasives and refractories are the fused alumina abrasives and fused magnesia, the refractory grade being used for bricks, crucibles, &c., and the electrical grade for the manufacture of tubular heating elements for stoves, &c. Progress in this field is described by J. A. Upper.†

CARBIDES, BORIDES, NITRIDES, SILICIDES

Many of the best known members of this class were described by Moissan in his book, "The Electric Furnace," published in 1897. An outline of their development is given by G. R. Finlay.† Tungsten carbide first appeared in Germany in 1914, but attracted little attention until a cemented carbide became available in 1927 as Widia, the descendants of which are now known under a variety of trade names. Cemented carbides have been used in rock drilling and wire drawing as well as for tool tips and wear-resisting surfaces. Titanium carbide is not only an important ingredient of some grades of steel-cutting cemented carbides, but is the basis of a new group of cemented carbides which may have important high-temperature applications. Continuing his review, G. R. Finlay refers to the manufacture, about 1933, of boron carbide, which marked the first commercial production of a material harder than silicon carbide. This material, under the trade name of Norbide, is claimed to be the hardest material made by man. It has many applications in which wear-resistance is of importance, and it is also extremely resistant to high temperatures. There are other promising materials of this class but their high cost hinders their development and commercial application. There are possibilities of reducing cost as shown by recent reduction in price of high purity boron

* *Stahl und Eisen*, May 8, 1952, page 539.

† *Archiv für das Eisenhüttenwesen*, 1935–36, Vol. 9, page 607.

‡ *Journal of Metals*, May 1952, page 469.

† *Journal of the Electrochemical Society*, March, 1952, Vol. 99, pages 51C to 66C.

nitride, and the situation would be improved if there was a larger demand for these materials.

Ferro-Alloys

This aspect of the subject was dealt with by J. H. Brennan,† who recalled that low-carbon ferro-alloys of chromium, manganese and vanadium were formerly made by the alumino-thermic process. F. M. Becket developed the silicon reduction process of manufacture of low-carbon ferro-chromium, the production of which has been of extreme importance in the metallurgy of stainless steels. In France and in England, processes based on the intermediate production of ferro-silicon-chromium (i.e., based on the Perrin process) have found application in low-carbon ferro-chromium manufacture; these processes have had only transient use in the United States.

Electric Furnaces

The collection of papers contained brief references to the use of the electric furnace in the production of phosphorus and of calcium carbide; and in conclusion there were papers by H. S. Newhall† and by G. H. Clamer,† respectively, on electric furnaces in the iron and steel industry and electric furnaces for the melting of non-ferrous metals, improvements in arc furnaces and the parallel development of induction furnaces being described.

Steel Forgings

The issue of *Stahl und Eisen* for June 5, 1952, was devoted almost exclusively to the metallurgy of heavy forgings, and contains information about German practice in the production of ingots, their manipulation and rolling, heat-treatment and machining, and about the properties and methods of testing of the finished forging. The treatment is not, of course, fully descriptive of the processes referred to; only certain selected aspects of the subject are dealt with.

In the first paper, by S. Ammareller and P. Grün,[1] steels for big forgings are considered. Forgings may be made of open-hearth steel (acid or basic), or, if the highest grade of forging is desired, from basic electric steel. In working the ingots, a reduction of $2\frac{1}{2}:1$ or $3:1$ (measured on cross section) is desirable as this gives a good combination of longitudinal and transverse properties. Special care is taken of the forging after completion of the forging operation to avoid cracks and internal stress. The demand for a minimum impact value often prevents the use of carbon steels or steels of very low alloy content. Though this demand is doubtless in accordance with results of prolonged study of components which have given good service, indications derived from the investigation of failures are, in the opinion of the authors, inconclusive. The development of the steam turbine, however, introduced a new demand and led to emphasis on creep properties. The 0·2 per cent yield stress was no longer a useful basis of calculation; proof data from long-time experiments were essential.

The choice of steel is governed by availability of alloy elements, as well as by the properties demanded and the governing section at the time of heat-treatment. Thus, for high-grade forgings, nickel-chromium-molybdenum and chromium-molybdenum-vanadium steels came into service, though wartime restrictions showed that alternative steels often proved to be satisfactory. A list of the different steels used for forgings in Germany, and their mechanical properties after heat-treatment in various sections, has been issued by the Verein Deutscher Eisenhüttenleute under the title *Stahl-Eisen Werkstoffblatt 55*6, and the authors describe at some length the characteristics of some of the steels, comparing them with some American and British steels. The list (following DIN 17,006) includes carbon, manganese and manganese-silicon steels, 0·4 per cent molybdenum steel and nickel steels with nickel up to 2 per cent. A few of the compositions with higher alloy content are reproduced in Table I, and some of the numerical test data given in the paper are plotted in Fig. 1.

The quality of a forging is dependent, in the first place, on the quality of the ingot from which it is made, and W. Heischkeil[2] discusses the influence of manufacturing conditions in the steel plant on the quality of forging-grade steel ingots. After reviewing the literature relating to defects in heavy forgings—longitudinal cracks, piping, segregation, blow-holes, flakes and non-metallic inclusions—the author discusses the effect on these of melting and casting practice and of hydrogen in the steel. The next paper, by W. Knackstedt,[3] deals with the manipulation of forgings and contains descriptions, with illustrations, of German and American forging plant, equipped with manipulators.

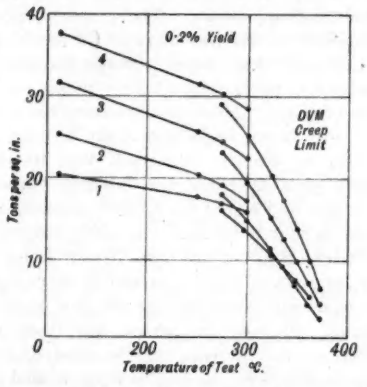
The influence of manufacturing conditions on the properties of large forgings for steam turbine sets is dealt with by R. Schinn.[4] He favours the use of small ingots. The size, however, must be consistent with the possibility of applying sufficient work in producing the finished forging. To meet this requirement he advocates intermediate upsetting. The carbon and alloy content necessary are governed by the mechanical properties required. To obtain these with minimum alloy content, the forging must be bored before treatment. Tests on nickel-chromium-molybdenum rotor steel forgings are quoted, showing that air cooling from 870 deg. Cent. followed by tempering at 600 deg. to 650 deg. Cent. gives properties which are uniform over the cross section, and are adequate provided that the molybdenum is not too low (i.e., about 0·3 per cent). Steels of lower molybdenum content (e.g., 0·1 per cent) show lack of uniformity when oil-hardened and tempered at 600 deg. Cent. Water hardening of such low-molybdenum steels gave non-uniform properties after tempering at 625 deg. Cent. and extreme lack of uniformity, doubtless accompanied by internal stress, when tempered at 525 deg. Cent. Some results are illustrated in Fig. 2, with details of the steels in Table II.

Reference was made in a paper by E. Scheil and R. Schnell[5] to the characteristics of some non-metallic inclusions in steel forgings. Manganese sulphide in steel, although brittle at a free surface, is surprisingly deformable if totally enclosed in the steel. The deformability of sulphide inclusions, relatively to that of steel, is independent of temperature over a wide range, lagging behind that of the steel to a greater extent, the greater the deformation. Oxide inclusions, on the other hand, are so hard at low temperatures that they are either not deformed, or are shattered. At a high temperature, however, they have a softening point like glass, and their deformability is ultimately no greater than that of the steel. The softening point of an oxide inclusion is higher the greater its silica content. An iron-manganese-silicate inclusion containing 50 per cent of silica has a softening point at 900 deg. Cent.; one with 66 per cent of silica at 1100 deg. Cent. Measurement of the deformation of manganese sulphide inclusions supplies evidence of the amount of deformation undergone by the steel during forging, whereas the deformation of silicate inclusions can give some indication of the temperature at which an ingot was forged or rolled. As already noted, the softening temperature varies with the composition; if necessary, material from the core may be used to determine the softening temperature of the oxide inclusions present.

The machining of heavy forgings in Germany is dealt with in a well-illustrated paper by H. Dürr.[6] In this, descriptions are given of modern machines for turning and boring, planing, milling and boring, grinding, &c. In the last paper in the series, R. Schinn and U. Wolff[7] describe recent developments in the ultrasonic testing of heavy forgings, with special reference to the reflection method. The detection of flaws, and their position, size and direction, was good, but to distinguish between dangerous and harmless defects was not always possible without the aid of other evidence.

Table I—*Chemical Composition and Minimum Yield in 20in Diameter Forgings*

Identification mark, DIN 17,006	Composition, per cent					0·2 per cent yield stress, minimum
	Carbon	Chromium	Molybdenum	Nickel	Vanadium	
						Tons/sq in
34 CrMo 4	0·30–0·37	0·90–1·2	0·15–0·25	—	—	25·5
22 CrMo 4	0·19–0·26	0·90–1·2	0·20–0·30	—	—	25·5
22 CrMo 4 4	0·19–0·26	0·90–1·2	0·40–0·50	—	—	29
28 NiCrMo 4	0·24–0·32	1·0 –1·3	0·20–0·30	1·0–1·3	—	29
28 NiCrMo 4 4... ...	0·24–0·32	1·0 –1·3	0·40–0·50	1·0–1·3	—	29
24 CrMoV 5 5	0·20–0·28	1·2 –1·5	0·50–0·60	—	0·15–0·25	35
28 NiCrMo 7 4... ...	0·24–0·32	1·1 –1·4	0·30–0·40	1·8–2·1	—	38



Curve 1, 0·4 per cent Mo; Curve 2, 1 per cent Cr–0·25 per cent Mo; Curve 3, 1 per cent Cr–0·5 per cent Mo; Curve 4, 1·5 per cent Cr–0·5 per cent Mo–0·2 per cent V.

The DVM creep limit is similar to the Hatfield time yield.

Fig. 1—*High-Temperature Properties of Molybdenum, Chromium - Molybdenum and Chromium - Molybdenum-Vanadium Steels (Minimum Values)*

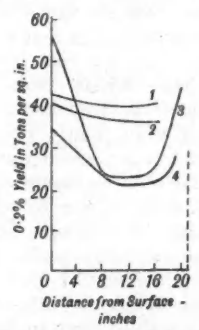


Fig. 2—*Yield Stress of 27-ton Rotor Forgings at Different Distances from the Outside (for Details, see Table II)*

Table II—*Details of 27-Ton Rotor Forgings Represented in Fig. 2*

Outside diameter 45·2in. Bore diameter 3·6in. Thickness of Wall 20·8in.

Curve No.	Composition of steel, per cent				Treatment, temperatures in deg. Cent.
	Carbon	Nickel	Chromium	Molybdenum	
1	0·27	1·88	1·17	0·33	870 deg./oil, 605 deg /air
2	0·27	1·93	1·21	0·31	870 deg./oil, 600 deg./furnace
3	0·27	1·68	1·15	0·11	870 deg./water-oil, 510 deg./air
4	0·27	1·68	1·15	0·11	870 deg./water-oil, 625 deg./furnace

[1] *Stahl und Eisen*, June 5, 1952, page 653; [2] page 663; [3] page 668; [4] page 676; [5] page 683; [6] page 687; [7] page 695; [8] page 708.

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THE IRON AND STEEL PRODUCTIVITY REPORT

LAST year, under arrangements made by the Anglo-American Council on Productivity, a team selected by the British iron and steel industry spent six weeks in the U.S.A. studying the organisation and methods of a part of that country's vast iron and steel industry. The British Iron and Steel Federation and the Iron and Steel Trades Confederation were jointly responsible for organising the team, which carried out its task under the able leadership of Sir Charles Goodeve, Director of the British Iron and Steel Research Association. The members of the team did some useful preparatory work prior to sailing, by visiting together various steel plants in this country, an action which enabled them to determine the methods of investigation they would follow in the U.S.A. In all the team visited eight American plants, five of which were in the south and west of the U.S.A. That may seem but a small number when the size of the American iron and steel industry is considered. But the account of the tour, the impressions gathered by members of the team, and the suggestions which they have framed—all of which are included in the report published this week by the Anglo-American Council on Productivity—cannot fail to prove of interest and value to all engaged in the British iron and steel industry.

In studying the report it must be borne in mind that the American steel industry is about six times as great as the British and that better quality raw materials and fuel are available to it. These are factors, of course, which influence productivity considerably in the U.S.A., a matter which the team has examined in some detail in the report. The information gained shows that the average production per unit of plant and per man-hour in the steel industry of America is about twice that in the British steel industry. Even so, it is encouraging to realise that the cost of steel manufacture in this country is lower than in any other country in the world, apart from Australia. That, however, is a position which can be maintained only by the continuous modernisation and the most effective utilisation of steel-making plant. The report directs attention to the fact that in all sections of the British iron and steel industry the greatest limitation upon productivity to-day is the size of plant. Modern blast furnaces which are now being built here have a capacity, so far as size is concerned, two to three times greater than the present national average, and one of the team's recommendations is that a minimum hearth diameter of 25ft for imported ore and 27ft for home ore for furnaces on basic iron should be accepted as a normal standard in all new developments. Equally important, the team suggests, is an increase in the size of open hearth furnaces, especially from a fuel and refractory point of view. Nevertheless, about open-hearth practice generally, the impression remains with us that the British steel industry has little to learn from its American counterpart. On rolling mill practice, the report makes some comments that merit careful study in this country. In the mills which the team visited a high standard of layout was apparent, the manual effort being much reduced by the greater use of mechanical aids than is common here. Yet productivity comparisons are difficult so far as the rolling mills of the two countries are concerned, for the U.S.A. derives much advantage from the smaller number of sizes rolled and the elimination of small tonnage orders and odd sizes. But there is much more in the report than we are able even to touch upon here. There is, for example, a chapter on the most suitable size for a steel works and on the problems of transport both of raw materials and finished products. The report urges that all integrated steel works should aim at a standard output of 750,000 to 1,000,000 ingot tons annually and expresses the team's belief that many improvements in the layout details of British works are possible, despite existing limitations. The transport problem is no less important. In this country the cost of rail transport represents 10 per cent of the cost of steel, despite the short hauls. The team thinks the apparently low productivity both of labour and rolling stock ought to be examined, especially with the object of increasing wagon and train loads above their present values. It adds that British Railways should be allowed a higher rate of capital expenditure for re-equipment—a suggestion which few, if any, are likely to disapprove.

Taken in its entirety the iron and steel productivity team's report is a very welcome document, not only for the information it presents on American conditions and practice, but also because it pinpoints many of the problems now confronting the British iron and steel industry. Moreover, the report has come at the time when that industry is completing the preparatory work associated with its second post-war development plan. The actual details of that plan are not yet finalised but it is being formulated on the basis of increasing this country's steel production to at least 20,000,000 ingot tons a year and pig iron output to 15,000,000 tons a year. Needless to say, such further expansion beyond that provided for in the existing development plan will make heavy claims on raw material and fuel resources, apart from requiring extensive capital investment. In carrying its plans to their final completion, the British iron and steel industry will undoubtedly adhere to its creditable objective of keeping production costs as low as possible, without sacrificing anything in the way of technical efficiency. The guidance to that end afforded by the productivity team's report will be of inestimable benefit.

ROCKET DEVELOPMENT

FROM time to time Ministers make encouraging statements on the development of guided missiles in this country, but little official information is available of the progress so far achieved. In his memorandum on this year's Navy Estimates the First Lord referred to the guided missile as "the most promising weapon in the anti-aircraft armoury for use at ranges between those at which our fighter aircraft and our anti-aircraft guns can operate." More recently the Minister of Supply announced that remarkable progress had already been achieved in the development of the guided rocket, which, he said, would add appreciably to our security. Neither of these statements adds much to our knowledge of guided missiles apart from indicating that we are developing them mainly for defensive purposes, but the Chief of Staff of the United States Army is more definite. The new anti-aircraft guided rocket, he states, will be able to destroy aeroplanes at altitudes above 60,000ft, and all three United States Service Chiefs make no secret of the great value they attach to all forms of rocket—guided and unguided—both for offensive and defensive purposes.

The short-range rocket, with solid propellant, was extensively employed by all belligerents in world war II for pre-assault barrages, and has also been developed for firing from aircraft. For, having no recoil, a rocket can be fired from a simple light tube, which serves merely to point it in the right direction, and there is none of the shock to the aircraft's structure that would result

from the firing of a gun of the same size. Rockets for aircraft use can thus be much larger with considerably more explosive power than a shell, and the post-war United States rocket, "Mighty Mouse," 2·75in in diameter with folding fins, can be carried in all types of modern aircraft. Another rocket used by aircraft with great effect against tanks and personnel in Korea has a 6·5in shaped charge. The United States Navy is now to have a new air-to-air rocket for use in naval fighter and interceptor aircraft. It is small enough to be carried in quantity in high-speed aircraft and has much greater range and velocity than those used hitherto. Rockets for use in both carrier-based and land-based aircraft consist of fixed-fin, folding-fin and spin types and vary in size from 2in to 14in and in weight from 9 lb to 2300 lb. The heads may be armour piercing, semi-armour piercing, high explosive, flare, smoke, and shape-charged. A rocket has also been designed for amphibious warfare, for use between the time the naval bombardment has to be shifted inland and the time the first assault wave reaches the shore. During this period, when the defenders can concentrate a heavy fire on the attacking forces, small craft fire a barrage at close range of 5in spin stabilised rockets against enemy strong points. Finally, solid propellant rockets are now available for firing at submerged submarines. Their motor tube—the combustion chamber in which the propellant providing the motive power is burnt—is of the conventional type and they are fitted with a fuse made alive by hydrostatic pressure and detonated when the rocket hits a solid object. Improvements in radar and electronic computers have now made possible a guiding mechanism for the long-range rocket, for which a liquid fuel propellant is required. The unguided V2 rocket fired on London by the Germans in world war II at a range of about 220 miles was a large but very inaccurate missile, with a destructive effect little greater than the far less complicated and more easily produced V1 flying bomb. Since the war similar large rockets, and also smaller long-range rockets for firing at aircraft have been developed, which can be guided throughout their trajectory, and already a 12,000 lb guided rocket has been successfully tested in the United States. But the development of the large guided rocket has received a further stimulus as a result of the recent reduction in the size of the heavy and cumbersome detonating gear for atomic explosives. Whereas formerly the use of atomic explosive was restricted to a bomb requiring a very large aircraft to carry it, it now appears that it can be used as the warhead of a rocket or for mines, torpedoes and other conventional missiles. One of the main problems still under investigation is to find the most suitable liquid fuel propellant for the guided missile. Tests have been made with such compounds as ammonia, hydrogen, hydrocarbons, alcohol and ethers for fuel and with hydrogen peroxide and pure liquid oxygen for the oxidiser. But each has its disadvantages and much more research will be required before an entirely satisfactory propellant combination is discovered, both for very long-range atmospheric rockets and for anti-aircraft missiles, which have different requirements.

The effect on naval operations of an atomically charged long-range guided rocket is likely to be profound. Hitherto the bombardment of shore targets from the sea has never achieved much, but the use of long-distance atomic missiles at once makes it a worthwhile operation—probably more worth while than the bombardment of the same targets from the air, in view of the difficulty bombers have in penetrating modern anti-aircraft defences. The United States Navy is at the present time rearming two cruisers with guided rocket launching platforms and there is no constructional difficulty in similarly equipping a submarine, which could carry one large atomically charged guided rocket. Surface ships of the stronger navy, besides being able to bombard shore targets to good effect, will be given much greater offensive power and a relatively small, fast capital ship may well replace the very large aircraft carrier as the fleet's principal weapon carrier. On the other hand, submarines of the weaker navy—if their enemy's merchant ships are adequately escorted—may find the bombardment of hostile towns and other centres of industry and population with atomic rockets easier and more profitable than attempting to deny the use of the seas to their enemy. With the immense force of submarines which Russia has in service it would not be surprising, in the event of war, if she allocated a substantial number to carry out operations of this kind.

Literature

The Non-Destructive Testing of Metals. By R. F. Hanstock, Ph.D., F.Inst.P. London: Institute of Metals, Monograph and Report Series No. 10, 4, Grosvenor Gardens, S.W.1. Price 21s.

In this attractive monograph, the author has interpreted the meaning of "non-destructive testing" in its widest sense, and has devoted chapters to very nearly every aspect of the subject. Dr. Hanstock writes with authority from a wide personal experience and his book is therefore not a mere collection and recording of other people's work; his approach is critical and the information is well selected. The author of a book of this kind is faced with a difficulty when abstracting the contents of other published papers. If his abstracts are too short, the reader must turn to the original papers; if they are too long, the book becomes unnecessarily padded. Hanstock has been successful in striking a nice balance between the extremes, and has supplemented the information selected for detailed reference by a good bibliography at the end of each chapter.

There is perhaps a little unevenness in some respects in the choice of subject matter. For example, the chapter on thickness measurement is confined to the methods of measurement from one side of a metal plate only. It is a little difficult to understand why the author should have confined himself to this aspect of the problem because methods for gauging materials, where the measuring device can span the thickness, are of great importance. Such devices range from the simple micrometer to the continuous strip thickness gauge and all of them can be properly described as non-destructive methods.

Of the continuous gauging instruments, much has been written, and electromagnetic devices, pneumatic and X-ray methods all have been extensively applied, and the chapter would have been very much improved by a review of these methods. It is realised that the selection of the contents for such a book is difficult in view of the vast field involved, but it is felt that this chapter would be worthy of extension in any future revision of the book.

Dr. Hanstock comes into his own in discussing the methods of determining the damping capacity of metals and perhaps goes beyond the title of his book in dealing with the theoretical and metallurgical aspects of damping capacity quite apart from testing methods. However, these chapters are extremely well written and are a welcome addition to the existing literature. The method of test referred to by le Rolland under the name of Elasticimètre Pendulaire and consisting of two identical pendulums mounted on a suspension made of the material for test is not dealt with, however, although it has aroused some considerable interest, particularly in France. It is claimed that the method can give accurate results, both in determining the elastic and anelastic properties and is not confined to metals.

The author states that one of his main objects was to indicate the limitations and advantages of the different methods available for each type of test. He has realised this object very well, and his book serves as an excellent starting point for anyone who wishes to go further into the subject. The high standard which the Institute of Metals has set in this series of monographs is well upheld by the present volume.

BOOKS RECEIVED

Patents, Designs and Trade Marks. By Charles S. Parsons. Surrey: The Technical Press, Ltd., 5, Ave Maria Lane, Ludgate Hill, Gloucester Road, Kingston Hill. Price 14s.

Practical Mathematics, Vol. I. Third edition. By Louis Toft and A. D. D. McKay. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 20s.

Analysis of the Four-Bar Linkage: Its Application to the Synthesis of Mechanisms. By John A. Hrone and George L. Nelson. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 120s.

Plastics Progress: Papers and Discussions at British Plastics Convention, 1951. Edited by Phillip Morgan. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 50s.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

STEAM-DRIVEN ALTERNATOR SETS

Sir,—We are anxious to find out if there are any Ferranti steam-driven alternator sets still in existence, working or otherwise. The type we are particularly interested in, with a view to its preservation, is the vertical cross compound type with the alternator direct mounted on the crankshaft and the cylinders fitted with the four-grid valve arrangement controlled by quick-opening and closing cams. These engines were built about the period 1900 to 1904 and were installed in a number of electricity generating stations throughout the country and also at some private plants. Unfortunately, our records of that period are very sketchy and it has occurred to us that one of your readers may know of the existence of such an engine. We have found one still working in Lancashire of an earlier design, which was fitted with four slide valves per cylinder, rope-driving a weaving shed still doing the job it was bought to do over fifty years ago.

A. W. G. Tucker

Ferranti, Ltd.,
Hollinwood, June 19th.

British Iron and Steel Productivity Report

ON Monday last there was published by the Anglo-American Council on Productivity, 21, Tothill Street, London, S.W.1, the report of a productivity team representing the British Iron and Steel Industry, which visited the United States of America in 1951. A foreword signed by the members of the team concluded by saying that the object of the report could not be served without self-criticism, stated or implied, but it was hoped that such criticism would not be misused and should be considered as a stimulus to further achievement.

The report commences with some remarks on products and markets and notes that the market served by the British industry is only one-sixth as large as the American and, because of the larger proportion of exports, is much less standardised. In America the ranges of product size and qualities have been substantially reduced and broader tolerances and less rigid specifications of finish encouraged.

Raw Materials.—On raw materials the report states that the average iron content of all ores consumed in Britain, based on the 1950 usage of 60 tons of home ore to 40 tons of imported ore, is about 40 per cent, compared with about 50 per cent in America. The use of more of the richer imported ores would obviously increase British ironmaking plant, fuel and labour productivities, and steps to achieve this are already being taken. American coking coal is on the average of better quality than British; it is easier to mine and therefore relatively cheaper. British blast furnaces operate nearer to the minimum coke consumption rate than American, but there is still room for improvement by better coking technique and improved screening and handling methods.

For open hearth and mill furnaces, America has the enormous advantage of abundant reserves of cheap oil and natural gas, which are piped to most parts of the country. The effect of these rich fuels on productivity is shown by the fact that about one-quarter of British open hearth steel production has been converted within the past five years from producer gas to oil firing with an increase of about 10 per cent in furnace outputs. In British soaking pits and reheating furnaces there is considerable scope for improvement in fuel consumption rates. Because richer fuels are plentiful, the works in the south and west of the U.S. do not conserve blast furnace and coke oven gases as British works have to do.

Works and Plant Units.—The team recommends that all integrated steelworks should aim at an annual capacity of 750,000 to 1,000,000 ingot tons. As regards units of plant, it recommends standards for future development. Blast furnaces should have hearth diameters of 25ft where imported ore is used and 27ft where home ore is used; cold metal open hearth furnaces should tap 150 tons, hot metal (fixed) 225 tons, and hot metal (tilting) 350 tons; primary rolling mills should have annual capacities of 750,000 tons. Some steelmakers in Britain have already reached these standards and as a result of developments at present in hand, several others will reach or exceed them. It will be necessary for British development and re-equipment to be concentrated in the works most suitably situated for expansion and this process is already under way.

American steelworks plant is driven at high rates. To a large extent this is attributable to the purity of raw materials and fuel, to size of plant units, and to other characteristics peculiar to the American industry. But even after allowing for these, American steelworkers are still able to get 10 per cent to 20 per cent more out of each unit of plant than we do in Britain. In blast furnaces this is accomplished with some increase of coke consumption (which the Americans can afford) and in open hearth furnaces with a reduction in roof life (which they accept). The rolling mills, however, seem to take fast driving with little if any increase in shut-down or maintenance costs. There is no case for a blind following of American operating rates, but there is a case for a continuous study of all modern methods to increase the operating rate of each individual piece of plant.

American manning per unit of plant is generally lower than in Britain, despite higher outputs. Mechanical aids and handling equipment are used wherever practicable, both to economise on labour and to enable continuous operation at a good speed. The difference in manning rates is particularly noticeable for steel furnace maintenance, where the greater working space provided in melting shop layouts and the provision of many effective mechanical aids result in a considerable reduction in plant downtime.

Labour. Training, Safety.—A large measure of uniformity in wages and conditions exists in the American industry, wage contracts being negotiated by the United Steelworkers Union with the various companies, using as a basis "job evaluation." This system is claimed to have eliminated previous inequities and to have reduced grievances. Output bonus schemes are somewhat less common than in Britain, but where they do exist they are direct and effective. Industrial relations seemed good at local level, although less stable than those in the British industry, where there has been no major dispute for over forty years. American training schemes and welfare activities are no better than those in the average progressive British firms. Safety consciousness, however, appears to be substantially better and intensified efforts are required here to improve the British position.

Transport.—Despite much higher American wage rates, the rate per ton-mile for ore and coal on American railways is two-thirds or less of that in Britain, due largely to the very much greater American train and wagon loads.

Research.—Research inside the American steel industry is on a relatively small scale, owing perhaps to the comparatively simple metallurgical problems in that country.

Development.—The cost of making iron and steel in Britain remains low by international standards. It can, however, only be kept so by continuous modernisation and the most effective utilisation of plant. Capital development since the war, together with increased use of fuel oil and the introduction of the continuous working week, has already given an increase of 25 per cent in the output of finished steel per man.

American firms are allowed by the Government to write off capital cost of plant and buildings more rapidly than are British firms. The capital cost of an integrated steelworks on a new site is estimated at £75 per ingot ton of capacity; unless the higher capital charges involved in new investment are more than offset by the operating economies secured through an increase in plant or labour productivity, then productivity in its widest sense has declined. Even after taking account of this factor the team urges a continuation of at least the current expenditure by the British steel industry. At present prices £30 millions must be spent each year merely to maintain existing capacity. Plans are, however, now being made to increase the present capacity, and the team considers that an annual capacity of around 20 million ingot tons could be reached in a reasonable time only if annual capital investment of £60 millions is maintained or even exceeded.

Following the publication of this report, the British Iron and Steel Federation, in a statement, said how welcome it was, not only for the information on American practice, but also for the light it cast on current British problems. The statement referred to the first development plan published in 1946, which aimed to raise steel production from 13 to 16 million ingot tons a year, necessitating an increase in pig iron production from 8 million tons in 1946 to an annual rate of 10½ million tons. Both these increases, the statement continues, were achieved. The second five year plan now being formulated is hoped to realise a steel production of at least 20 million ingot tons. New sources of ore, particularly in Africa, were being developed, and steps were being taken to increase the supply of coking coal by 7 million tons a year. The statement explained the need for extensive capital investment in the many components of a modern steelworks and concluded that the report would be of great value in assessing the practical possibilities of development in the context of British conditions and aiming at a minimum overall cost when transport, fuel, raw material and capital costs, as well as labour productivity, were taken into account.

Brassfoundry Productivity Conference

AT the brassfoundry productivity conference last week a number of papers were presented on both the purely foundry side and on the machining side of the industry. Some hundred companies were represented, fourteen papers were presented and a large number of films were shown during the proceedings. The most important papers concerning foundry methods were one on the use of aluminium alloy match plates and one on flexible cutting-off wheels. Since the productivity team returned from America sufficient work has been done on the technique of producing aluminium match plates for the authors of the paper, Messrs. E. C. Mantle and D. H. Potts, to consider that there is now no technical reason why they should not be produced in this country on a commercial scale and cheaply. There is as yet little demand for match plates, but the authors thought that they could be made available at a cost low enough to enable small jobbing foundries to use them. The American system is to base foundry production, using match plates, on one-man units. The use of match plates could be of advantage in Britain, as in America, it was considered, even for small jobbing foundries.

The potentialities of the flexible cutting-off wheel in the dressing shop were argued by Mr. C. A. J. Timms. Research has been going on in this field for some time, and a wheel is now available which is both flexible and, with normal usage, unbreakable; no suitable holding machine, however, was yet known to be manufactured. Like the match plates these flexible wheels could probably be produced cheaply if demand for them were high enough. These two developments offer the prospect of significant savings in production time to the brassfounder. A "cost clinic" was held for brassfounders during the conference. This adaption of what is a popular American method of providing opportunities for comparing costs proved equally popular at the conference. All entries had to be made with a detailed routing sheet for a stipulated job, on which production operations and times were detailed, and with a cost sheet giving cost of materials used and of manufacture. The main points emphasised in reviewing the papers submitted for the exercise were the prime need to plan carefully both the routing of a job and the amount of material required, the importance of only crediting the current value of scrap resulting, and the need to assess departmental overheads rather than adding an overall on-cost.

The papers concerning the machining side of the industry were largely an extension of what was said in the productivity team's report. Mr. F. E. Rattlidge in a paper on assembly, testing and inspection, compared a typical layout in this country with what he had seen in the United States. Mr. C. H. Wilson, in his paper on factory transport and storage, described how certain problems of handling and storage had been met. The problems of dealing with large numbers of small components were discussed, and the use of specially designed containers—"standard trays," the careful consideration given to layout, and the use of height in storage were considered methods by which difficulties had been overcome.

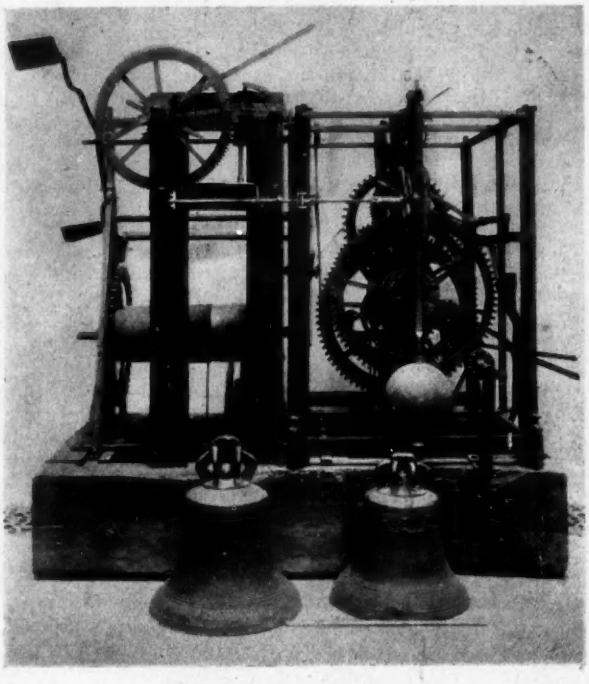
British Clockmaker's Heritage Exhibition

The British Clockmaker's Heritage Exhibition, now on view at the Special Exhibition Gallery of the Science Museum, South Kensington, London, is one of the most remarkable and comprehensive displays of time-measuring mechanisms ever shown to the public.

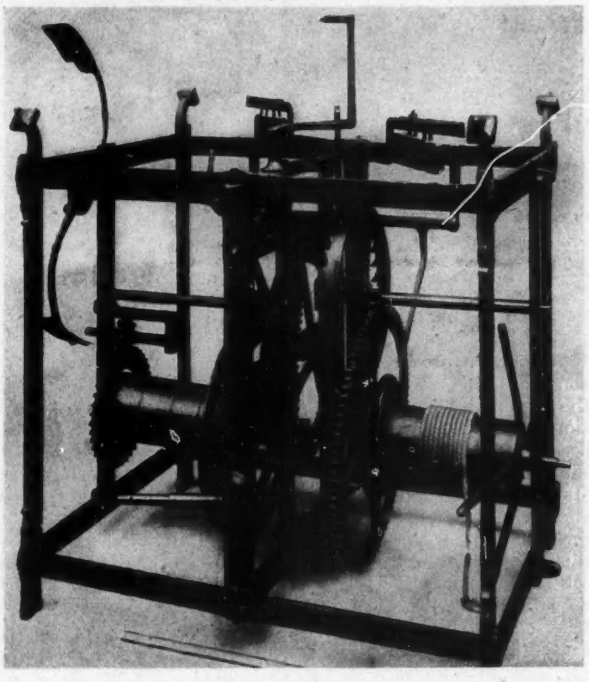
AN exhibition at the Science Museum, organised by the Antiquarian Section of the British Horological Institute to illustrate the developments of British clockmaking from the introduction of mechanical clocks up to about 1820, has an appeal that extends far beyond the sphere of the clock collector or, indeed, of the horological industry as a whole. Those engaged in every branch of engineering, and of the mechanical arts generally, will find much to interest them in the story, so ably told in the series of carefully selected exhibits, of the gradual triumph of the clockmaker over the many difficulties that beset his path in his attempt to produce a machine that would be capable of perfectly regular and ordered motion—for that is what a clock really is!

The exhibition is divided into two sections, the first being made up of exhibits illustrating the development of the clock before the invention of the pendulum and balance spring at about the middle of the seventeenth century. The second section consists of exhibits showing the progress made after the introduction of these two important pieces of mechanism, and traces the story onwards from about 1660 until 1820, by which time the main mechanical features of clock construction may be regarded as stabilised. The total number of exhibits, excluding a series of portraits of former masters of horology, is 379, and each individual specimen was chosen for its ability to exemplify some particular stage in the development of the clock.

The great iron clock formerly at Wells Cathedral, and dating from 1392, is the first mechanical exhibit in the "pre-pendulum" section, and shows very well the kind of time-keeper that was in use in the great monastic houses of the time. The framework of this clock, which is illustrated herewith, is made of forged bars, riveted together to form a kind of cage. Further bars carrying the bearings for the spindles of the wheelwork were attached to the main frame by tenons and wedges. The spindles, wheels and pinions were also of forged construction, the wheel teeth being formed by hand with the aid of dividers, chisels and files. There are three trains of wheels, one for timekeeping, a second for quarter chiming, and a third for striking the hours, and it is notable that, in its basic principles, the Wells clock is identical with the modern weight-driven, hand-wound tower clock. The "locking-plate" mechanism which governs the number of blows struck at the hour, is, in fact, unaltered to any appreciable extent, even on the most modern type of electrically driven striking mechanism.



WELLS CATHEDRAL CLOCK 1392



DOVER CASTLE CLOCK

The two following exhibits are of tower clocks of somewhat later date, one from Dover Castle, which can be seen above and the other from Cassiobury Park, near Watford. Both are particularly interesting by reason of their retention of their original "foliot" balances. These illustrate the type of time counting device used on all clocks before the coming of the pendulum. The Wells clock was also originally fitted with a "foliot," but has since been altered to take a pendulum and recoil escapement, probably about the end of the seventeenth century.

As the Dover and Cassiobury clocks demonstrate, the "foliot" was a very crude arrangement, the duration of each swing depending on the force available to drive the wheelwork, and on the friction of the various parts in engagement, so its timekeeping was distinctly poor. For this reason, clocks so fitted varied in time to an extent that may have been more than an hour a day.

The way in which the large clocks used in towers were scaled down in size to form the first domestic timekeepers is illustrated by the next exhibits, several of which are, in effect, models of the larger machines. The fine craftsmanship of these clocks is the more creditable when the crudeness of the tools and methods then available is appreciated.

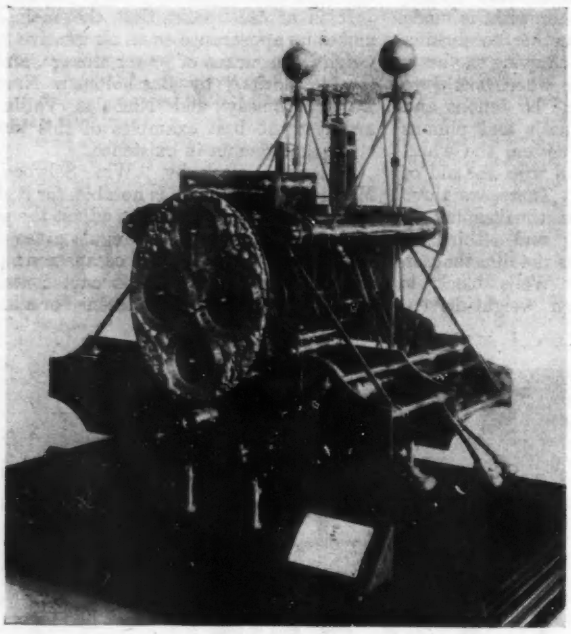
It is at this point that the mainspring makes its appearance as an alternative to the weight as a means of power storage, and the "table clocks" by Bartholomew Newsam, David Ramsay and Nicholas Vallin are amongst the best examples of this kind of clock that remain in existence.

A lantern clock by "Wm. Selwood, Ye Marmade, Lothbury," is notable, for it shows how attempts were made to adjust the power of the driving weight to regulate the timekeeping of the "foliot" escapement. The weight is in the form of a cup, containing lead shot, which could be lessened or added to to make the required adjustment. Another change that is well illustrated by this clock is the replacement of the oscillating bar of the tower clock "foliot" by a "balance wheel," which, though lacking a balance spring to give it the property of isochronism, had in it the beginning of the precise, balance-controlled escapements in universal use to-day.

The twelfth, and last, exhibit in this first section is a fine silver lantern clock, by "D. Bouquet, A Londres," which, though now converted to pendulum control, merits attention as a good example of the early use of brass for wheel and pillars. In most of the older clocks the material used for all parts was iron, but this was increasingly replaced by brass after the first few years of the seventeenth century.

The second section of the exhibition is divided into three parts, described in the catalogue as "Timekeeping mechanisms and clocks for scientific purposes," "Domestic clocks," and "Watches," respectively. With the coming of the pendulum, it became

possible to achieve reasonable precision in timekeeping, and the invention of the "anchor" or "recoil" escapement, a form still widely used for domestic clocks, constituted a further advance. As can be seen from the exhibits, these improvements made it necessary to construct better wheel trains and similar parts, for defects that were not apparent with less efficient escapements soon proved very detrimental to the performance of the more precise forms of time-counting mechanism.



HARRISON'S FIRST MARINE TIMEKEEPER

The first notable exhibit in this second section is a tower clock, originally at King's College, Cambridge. It was fitted with a pendulum and recoil escapement at the time of its construction, and is the work of the celebrated William Clement, of London, to whom some authorities attribute the invention of the recoil escapement. Its pendulum, which has a wooden rod, is of the long form that became popular when its good timekeeping characteristics were recognised, and the clock is also fitted with a "maintaining power," an attachment to keep the timekeeping mechanism in action during the winding of the driving weight.

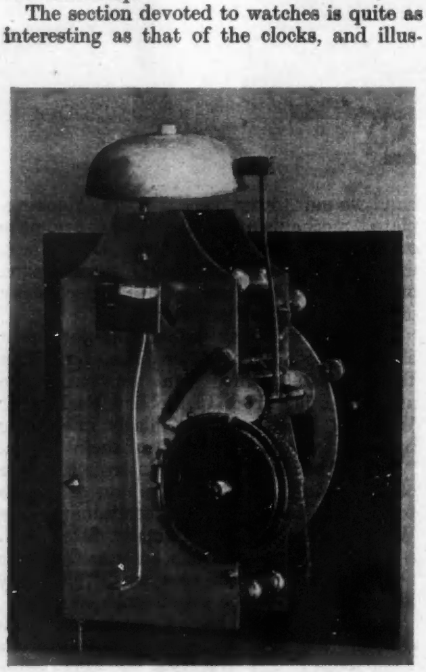
Other exhibits of note in the section include a "year-clock," by Thomas Tompion; two astronomical timepieces, by Samuel Watson; year equation timepieces, by Tompion and Quare; a month equation timepiece with annual calendar, by the celebrated George Graham, which is fitted with his "dead-beat" escapement; and a mercurial compensation to the pendulum, and a magnificent four-dial astronomical clock, by Eardley Norton, which was made for George III, and is shown by gracious permission of Her Majesty the Queen. A novelty in this part of the exhibition is a "Congreve" clock, in which the time-measuring function is performed by a small steel ball, which travels down an inclined zigzag groove in a metal plate. As the ball reaches the end of its travel it operates a small trip lever and so causes the plate to tilt in the opposite direction, thus setting the ball off on a fresh journey. At the end of this the cycle is repeated. As a timekeeper it is not particularly accurate, but it is interesting, for it shows the ingenuity of the horologist in devising unusual mechanisms.

The group of marine chronometers is one of the most important parts of the whole exhibition, for it includes John Harrison's first, second and fourth marine timekeepers, the last mentioned being the instrument which secured the £20,000 award offered by the Board of Longitude in the early part of the eighteenth century for "an instrument capable of enabling a navigator to determine longitude within half a degree." All three Harrison chronometers, the first of which can be seen herewith, are shown going. Other chronometers are by Mudge, Larcum Kendal, and Earnshaw, the last being of particular interest on account of its "spring-detent" escapement, an invention of Earnshaw's, which, with a few modifications, is now the standard form for marine chronometers.

The domestic clocks form an extensive exhibit, being 125 in number and including some of the finest and most famous in existence. With such a large group it is difficult to particularise, but three magnificent Tompions, a long-case, exhibit No. 142, and two bracket clocks, exhibits Nos. 117 and 131, show the high state of artistic as well as mechanical perfection that was achieved at this time.

Another fine example is a clock by John Fromanteel, a view of the movement of which we reproduce below. It has locking plate striking work and is notable for its narrow, upright frame plates, and fine craftsmanship.

The section devoted to watches is quite as interesting as that of the clocks, and illustrates the way in which the special difficulties arising in connection with the making of a reliable personal timekeeper were gradually surmounted. There are 182 exhibits, and the specimens selected for inclusion exemplify every stage of development, from the early form, which has distinct resemblance to the table clocks of the seventeenth century, to the beautiful lever movement, made in 1800 for the Prince of Wales by Josiah Emery.



JOHN FROMANTEEL CLOCK OF 1670

The various devices used in both clocks and watches to minimise friction and to obtain the utmost possible regularity of motion are so diverse and ingenious that it is not possible to describe them in any detail, but the exhibition makes it quite clear that the contribution of British horologists to the perfection of present-day timekeepers is larger than that of any other group of craftsmen. Without the many inventions made by them, no clock, as used to-day, could be constructed, and so the pride with which the organisers display this great collection seems amply justified.

If there is one criticism that can be levelled at the Heritage Exhibition, it is that it stops short at the beginning of the nineteenth century. This may give an erroneous impression that British progress in horological science flagged after that time, a thing that is most untrue. The fact that the organisers are the Antiquarian Section of the British Horological Institute probably accounts for the limitation mentioned, but so many great advances have been made since the middle of the nineteenth century that there seems ample scope for a further exhibition, which would bring the story up to date.

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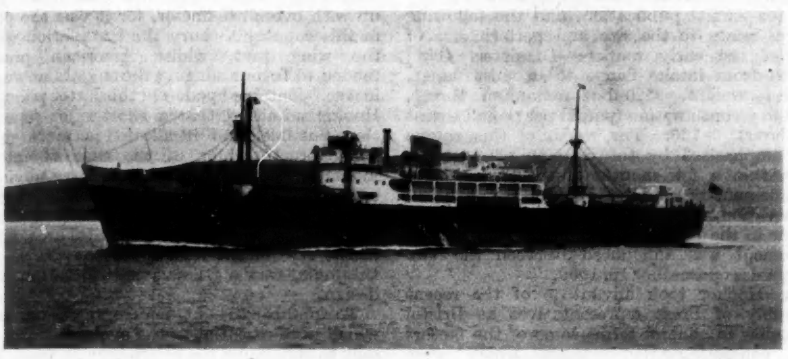
Welded Gas Turbine Blades

A NEW manufacturing process, which is expected to accelerate greatly the production of turbo-jet aircraft engines in the United States, has been announced by the General Electric Company of Schenectady. The process involves the fabrication of the stator blades of jet compressors in place of the relatively slow and expensive forging technique which is currently used. In addition to speeding up blade manufacture considerably, the process is expected to result in savings in critical materials and in jet engine manufacturing costs. The critical material savings are estimated at 39 per cent because of virtually chipless production, and cost reductions of 55 per cent in stator blade manufacture are claimed to be possible. In addition, considerably less production equipment is needed for the manufacture of fabricated blades as compared with forged blades, and the equipment is less costly than that used in forging. The U.S. Air Force has approved the substitution of fabricated blades for forged blades in the General Electric "J-47-GE-23" turbo-jet engine, which is going into large-scale production for the jet-powered Boeing "B-47" Stratojet medium bomber. The fabrication process has been approved only for the stationary blades, while the rotary blades will continue, for the present, to be forged because of the high centrifugal stresses involved. Limited production of blades for engine testing was begun late in 1950. Performance tests were run on two engines equipped with fabricated stator blades before any substitution was authorised. After 500-hour endurance tests, thorough examination showed no undesirable conditions or signs of future failure, and performance tests showed no change in efficiency compared to engines with forged blades.

The Cargo Liner M.V. "Ebro"

AFTER completing trials in the Firth of Clyde, the motor cargo liner "Ebro" sailed for London and, after loading, sailed on Friday of last week on her maiden voyage in her owner's cargo and passenger service from London to Bermuda, West Indies, Spanish and Central America. The main particulars of the "Ebro" are :—Length between perpendiculars, 415ft.; breadth, moulded, 58ft 6in; depth moulded to shelter deck, 38ft 4in; loaded draught, 25ft 3½in; deadweight, 8101 tons and 5855 gross tons. This latest addition to the fleet of the Royal Mail Lines, Ltd., has been built at the Govan yard of Harland and Wolff, Ltd., and a sister vessel, the "Essequibo," is at present fitting out at the same yard preparatory to entering service in the autumn.



CARGO LINER M.V. "EBRO"

The ship, which can be seen in our illustration, has a pleasing profile and is a complete superstructure vessel, having three continuous decks, namely, the shelter, main and lower decks, with promenade and boat decks amidships and a short forecastle. There are seven watertight bulkheads, which divide the ship into eight compartments, including five cargo holds, three being forward of the machinery space and two aft. No. 3 hold is fitted as a deep tank for the carriage of edible oil cargo. The hull is of mixed riveted and welded construction, the tank top and the butts of shell and deck plating are welded, while the framing and the seams of shell and deck plating are riveted.

All the accommodation is situated amidships and twelve passengers are carried in eight single and two double-berth rooms, each of which have a private bathroom attached. Our engraving of a single berth cabin illustrates the high standard of comfort provided for the passengers. The captain has a suite of rooms in a house forward on the boat deck, at the aft end of which is the passengers' verandah and lounge, part of which can be seen in the photograph reproduced on this page. At the forward end of the deckhouse on the promenade deck are cabins for the deck officers and to port and starboard are the passengers' rooms, while aft there is an officers' smoke room, the second engineer's cabin and the chief engineer's suite of rooms. The junior engineers are accommodated on the shelter deck, as are also some of the crew, the remainder having their cabins on the main deck. The dining saloon for passengers and ship's officers is situated at the forward end of the house on the shelter deck and service is from an adjoining all-electric galley, which also supplies the various messes of the crew, who have a recreation space provided for them at the aft end of the shelter deck. An innovation in the accommodation is the fitting of a Redifron communal aerial system.

There is a small laundry and ironing room, and Thermotank, Ltd., has supplied mechanical ventilation complete with filters throughout the accommodation, which has separate electric heating. Incorporated in the fresh water system is a "Uneek" filter, which is worked in conjunction with the chlorination system. On the main deck, immediately below the galley, are the ship's cold stores, with a capacity of 2850 cubic feet, which are cooled by an electrically driven methyl-chloride unit, supplied by J. and E. Hall, Ltd. Four 26ft wooden lifeboats, one fitted with a motor, are carried under Welin MacLachlan davits, and there are hand lowering winches and two portable electric motors.

For the handling of cargo there are twelve derricks for loads up to 10 tons, and at the forward end of No. 2 hatch is mounted a heavy derrick of 30 tons lifting capacity. The derricks are worked by Clarke Chapman electric winches, eight of 3-ton and four of 5-ton capacity, and this company has also supplied a number of topping units and the electric windlass. As a safety measure a Pyrene fire detecting system and carbon dioxide extinguishing system is fitted in the holds and store room. Brown Brothers and Co., Ltd., supplied the four ram electro-hydraulic steering gear; located on the steering gear flat is a Sigma pump, driven by a Petter diesel engine, which has its suction in the tunnel and supplies the fire main.

Main and Auxiliary Machinery

The ship is propelled at a service speed of 14 knots by a Harland and Wolff, B. and W. two-stroke, single-acting, opposed-piston, eccentric, crosshead diesel engine, driving a Heliston four-bladed propeller, manufactured by J. Stone and Co., Ltd., and weighing about 10 tons, of 16ft 3in diameter by 12ft 6in mean pitch and 102 square feet surface area. The engine, which is enclosed, forced lubricated, direct reversing, and arranged for airless injection, operates on both heavy fuel and diesel oil, developing 4500 b.h.p. at 115 r.p.m. There are six cylinders, in which the lower pistons have a diameter of 620mm by 1400mm stroke, and the upper pistons have a diameter of 622mm by 470mm stroke, to give a combined stroke of 1870mm.

The bed-plate and frames are of fabricated steel and the thrust block is incorporated in the bed-plate. Explosion doors are fitted in the crankcase covers and are equipped with guards which are designed to throw any blast upwards. Scavenge air is supplied by rotary blowers, having silencers fitted to the intakes, mounted on the back of the engine and driven by roller chains from the crankshaft. The cooling of the cylinders is by fresh water and that of the pistons by oil from the forced lubrication system, while the lower part of the cylinder liners is cooled by the air in the scavenge belt which is incorporated in the entablature. At the forward end of the engine and driven from the crankshaft are the main salt water and fresh water circulating pumps, which are of reciprocating pattern, having a maximum capacity of 200 tons and 180 tons per hour respectively, which varies with engine speed. Coolers of adequate capacity form part of the cooling water circuit.

During trials the engine has been running on heavy fuel of 1500 seconds Redwood 1 at 100 deg. Fah., and the fuel is pumped to a settling tank, then heated before passing through a purifier and a clarifier, supplied by Alfa-Laval Company, Ltd., capable of dealing with a nominal 2 tons per hour of fuel up to 3500 sec. at 180 deg. Fah., before being delivered to the clean tank. The system includes two filters one of "Clinsol" pattern, and the suction line to the fuel pump is lagged and steam line heated. There is a fuel oil transfer pump of 20 tons per hour capacity and a standby fuel pump of 5 tons per hour rating. Starting air is stored in a

CORNER OF LOUNGE

SINGLE BERTH ROOM

reservoir of 800 cubic feet capacity, supplied by two electrically driven compressors capable of delivering 120 cubic feet of air at 356 lb per square inch when running at 500 r.p.m. In addition, there is an emergency steam-driven compressor, which can deliver 10 cubic feet of air at 356 lb per square inch to a reservoir of 50 cubic feet capacity for the emergency starting of the auxiliary machinery.

The forced lubrication system is maintained by two self-priming lubricating oil pumps, one of which acts as a standby, and at the intake side of the pumps is a duplex filter of "Clinsol" design. In the circuit are lubricating oil coolers supplied by the engine builders, which have each a cooling surface of 1000 square feet and are capable of maintaining the oil at a temperature not exceeding 120 deg. Fah. with the sea water at 85 deg. Fah.

In the machinery space are two vertical thimble-tube boilers, supplied by the Newlin Boiler Company, Ltd., both of which operate at 100 lb per square inch and can generate 2250 lb of steam per hour. One boiler utilises the heat from the exhaust gases and the other is equipped with a Wallsend low-pressure system burning heavy oil under forced draught. G. and J. Weir, Ltd., has provided the feed pump for the boilers and a high-pressure distiller. The majority of the pumps in the engine-room are made by Drysdale and Co., Ltd., and are of "Centrex" pattern and electrically driven. In addition to those already mentioned there are an 85 tons per hour bilge pump, a ballast pump rated to deliver 170 tons per hour against a head of 50ft., a general service pump with a capacity of 200 tons per hour against 50ft. head, a standby general service fresh water circulating pump of 180 tons per hour, and auxiliary circulating pumps, one of 45 tons per hour for salt water and one of 40 tons per hour for fresh water. A Drysdale "Wee-Mac" fresh water pump supplies the ship's services.

The electrical supplies are provided by three diesel-driven generators, each having a rating of 135kW, 225V d.c. when driven at 450 r.p.m. by a Harland and Wolff four-cycle, single-acting, trunk piston diesel engine having six cylinders of 250mm diameter by 350mm stroke.

Ventilation of the machinery space is effected by four Thermotank supply fans, each of which delivers 50,000 cubic feet of air per minute, sufficient for forty-seven changes of air per hour.

The Bristol "Olympus" Turbo-Jet

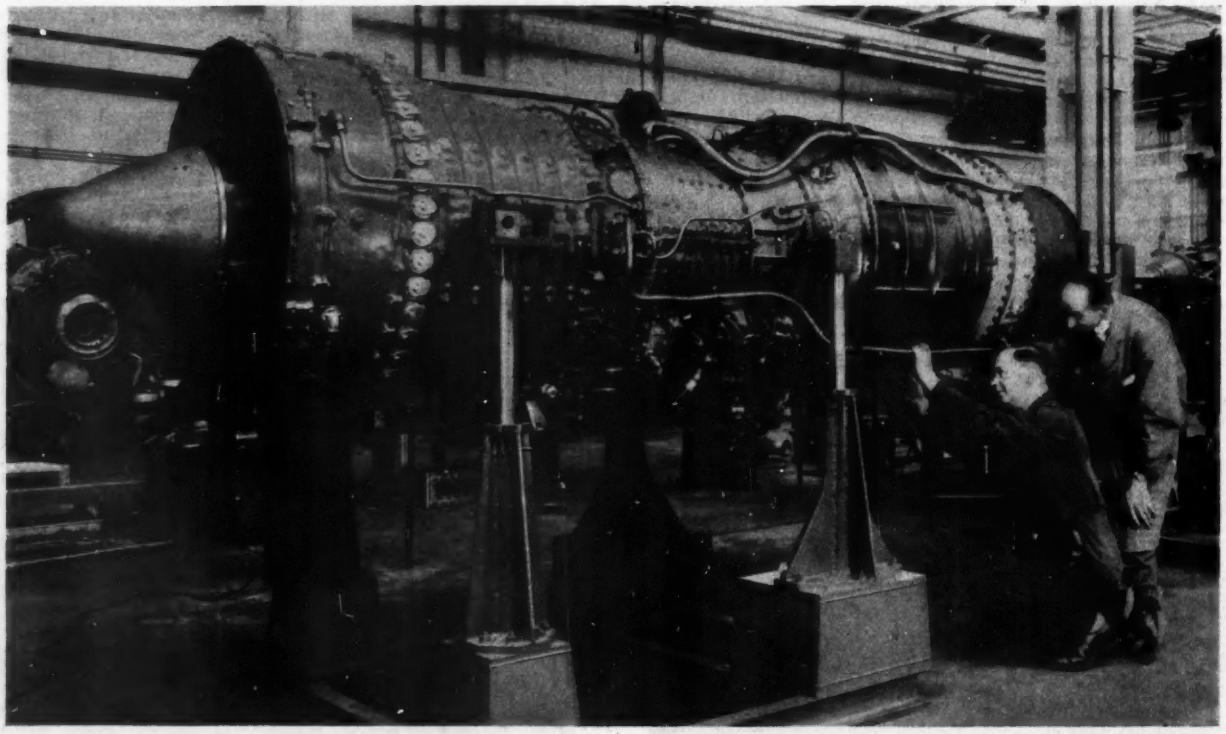
DURING a recent visit to Filton works of the Bristol Aeroplane Company, we were able to see on test an engine of which this company is justly proud. For the "Olympus" turbo-jet which has now been under development for three years, develops nearly 10,000 lb static thrust, is remarkably compact, and although employing only a very moderate temperature and component speeds, has achieved what is believed to be the highest thrust and the lowest specific consumption of any jet turbine in the world. The "Olympus" is also the first engine to compound two axial compressors in series, but apart from this important development the engine is of conventional design. Information was released on Monday last for partial publication, and the following figures relate to the size and performance of one of the early marks:—Diameter, 40in; length from intake flange to exhaust flange, 124in; weight, 3520 lb; maximum thrust, 9750 lb; consumption (pound per pound thrust per hour), 0·766. The worth of this engine was emphasised by the reaction of America, for within a few months of the engine's test bed demonstration the Wright Aeronautical Corporation asked for a licence to develop the engine in the United States of America, and an agreement was announced between the two companies on October 19, 1950.

Dr. Hooker took advantage of the recent assembly of Press representatives at Bristol to review in general terms some of the factors and conflicting requirements which were involved in the design of this important engine. The primary requirements of this engine were a thrust in excess of any existing engine without requiring much dimensional growth, and to have the smallest possible frontal area with the lowest possible fuel consumption. It was required also to restrict the temperature and the speeds to ensure a reasonable life, having in mind the established properties of available materials. Such a unit, therefore, fulfilling these requirements of high thrust with low fuel consumptions and long life would, at the same time, satisfy the long-range requirements of a bomber aircraft and favour the economic operation of commercial jet aircraft. Dr. Hooker claimed in very few words the advantage of axial over centrifugal compression, which, he noted, was up to 10 per cent more efficient. With respect to the geometry of the unit, the most important dimension was the overall diameter, particularly at transonic and supersonic speeds, and once again the frontal area obtained with an axial flow unit was characteristically smaller. In fact, with the "Olympus" an almost constant diameter had been achieved along the length of the engine.

Another controversial issue which, in this case, mainly affects American and British opinion, relates to the method of engine mounting. This factor was also closely tied up with overall diameter, for it was the policy in this country to bury the installation within the wing root, whilst American practice tended to favour slinging the engines externally in a self-contained pod. On this latter point, Dr. Hooker admitted that a shorter jet pipe was thus possible, and it allowed a more simple wing structure, for in the case of internal mounting the main wing spans have obviously to be holed to receive the engine. Nevertheless, he was absolutely convinced that the British method promised the lowest frontal area, which, in the case of the high speeds envisaged with this unit, was a primary consideration in its design.

To obtain the higher compression ratios which were essential to the cycle, it was necessary to compound the compressor in two stages. For, as was generally realised with single unit compression ratios much above 7:1, flexibility was impaired by the stalling of the front blades.

The "Olympus" consists basically of a low-pressure unit and a high-pressure unit mounted in series, each having an entirely independent axial compressor and turbine and each is driven through concentric shafts by its own separate turbine. This arrangement gives all the advantages of handling and easy starting obtained with engines of medium compression ratios. Its flexibility was very convincingly demonstrated at the test bed, where the engine was raised repeatedly from its self-sustaining speed



THE BRISTOL "OLYMPUS" TURBO-JET

of 2750 r.p.m. (100 lb thrust) to its maximum speed, which was less than 10,000, achieving on this very early mark of engine 9750 lb thrust, the throttle movement being best likened to a jab and taking less than a second to span its range. As Dr. Hooker remarked, very considerable engineering problems were involved in arranging so compact a compounded engine, but they all yielded to treatment. The arrangement consists very briefly of a low-pressure axial compressor mounted on roller bearings at one end, and ball bearings at the other, and connected to its turbine via a shaft incorporating a flexible joint with another roller bearing at the turbine. The high-pressure unit is mounted in series and thus concentrically around this shaft, and is mounted on ball bearings at the compressor end of the turbine connecting sleeve and roller bearings at its turbine. It also incorporates a flexible coupling. The present combustion system consists of the conventional combustion cans, but mounted in an annulus within which flows the secondary air. It is a further advantage of high compression ratios that the size of these cans can also be reduced, a factor which has, in fact, contributed to the low overall diameter achieved. The temperature spread has been reduced with the arrangement to 3½ per cent. It was stated also that an annular combustion chamber has been developed for this engine.

A Proportioning Pump

FOR some years an interesting design of proportioning pump has been made at the works of the Howard Pneumatic Engineering Company, Ltd., Fort Road, Eastbourne. These pumps were originally designed for use in the oil refineries for the injection of chemicals and dosing purposes, and they are being increasingly adopted by other branches of industry, particularly in chemical works.

These "proportiometer" pumps, as they are known, operate on a principle developed by Mr. H. E. Charlton, of Harold Moore and Partners (Engineers), Ltd., and the principle can readily be followed with reference to the diagram of a twin-cylinder unit we reproduce on this page. The pump has two pairs of cylinders, the plungers of which are reciprocated by a centrally placed common driving unit. The pair of cylinders at each end of the pump are connected to a common valve box incorporating the suction and delivery valves. These valve boxes are connected to the main suction and delivery line of the fluid being pumped. It will be noted that the plungers of opposing cylinders of the unit are connected to a common crank or eccentric in the driving unit. The cranks at each side of the driving unit are connected by differential gearing, and through this gearing the phase relationship of the plungers of opposing pairs of cylinders can be varied. When the plungers operate in phase the pump is delivering its maximum capacity, and when they are 180 deg. out of phase, the delivery is nil. This phase variation is effected through movement of the planetary bevel of the differential gear by means of a wormwheel.

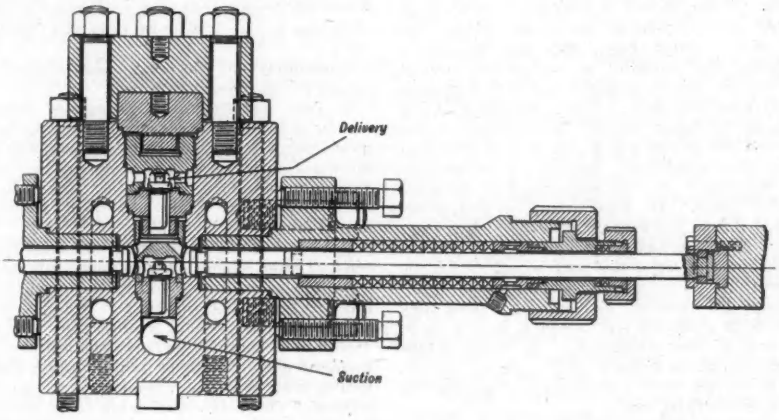
It will be seen in the drawing on the left of the diagram that the plungers are 180 deg. out of phase and the liquid in each pair of cylinders simply flows from one cylinder to the other in each pumping cycle. In the other drawing the full phase relationship has been restored, and both plungers at each end of the pump are delivering to maximum capacity. A handwheel operated wormwheel is used to turn the planetary bevel, and phase adjustment to give any required delivery between maximum and nil can be made whilst the pump is running.

In the course of a recent visit to the firm's works, we were shown one of the largest pump units of this design yet built undergoing its tests. This pump operates on the same principle in that delivery can be infinitely varied by changing the phase relationship of opposing plungers through a differential gearing, but its general arrangement is very different from the standard design of unit. It is one of a number of similar units supplied to a chemical company and has been designed for continuous operation, delivering 200 gals. of liquid per hour against a pressure of 5000 lb per square inch. The pumps are used in pairs, delivering two different liquids into a reaction vessel and, as the proportioning of the two liquids is critical, its delivery must be kept within close limits to prevent the reaction getting out of control. To effect this close control, it was decided to install "proportiometer" pumps in which the output could be adjusted as required during running.

As can be seen from the photograph and drawings we reproduce, the pump is a three-cylinder unit with its cylinder block in the centre of the bed. A separate drive unit with three plungers is arranged at each end of the pump and each opposing pair of plungers work in a single bore in the cylinder block. Inlet and delivery valve units are set in the cylinder block between each pair of plungers and are connected to the suction and delivery lines by common bores transversely through the block. The drive from the motor at one end of the pump is transmitted to the two plunger assemblies through the medium of a wormshaft and wormwheels. The drive is designed to transmit up to 25 h.p.

It will be appreciated that when opposing pairs of plungers are reciprocated fully in phase, they displace the maximum volume of liquid in the cylinder when their heads have reached the innermost position. As the phase is changed, the volume of liquid displaced and forced through the delivery valve varies accordingly. When the two plungers are completely out of phase, the liquid in the cylinder is pushed up and down the cylinder bore in each pumping cycle, no compression being effected to give any delivery.

The drawing of the cylinder and one of the plunger assemblies shows the straightforward design and heavy construction which has been



PLUNGER AND CYLINDER BLOCK ASSEMBLY

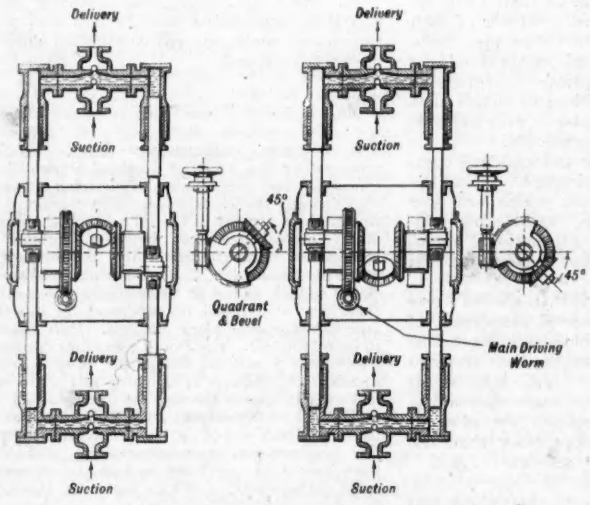
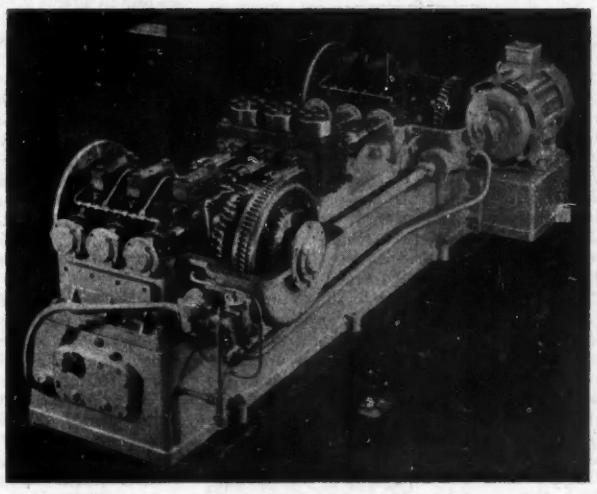
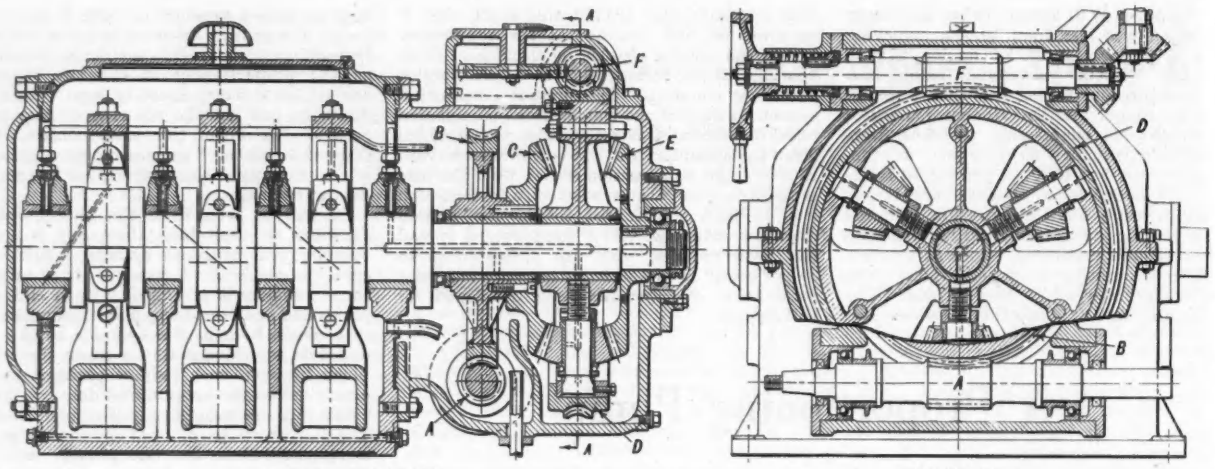


DIAGRAM SHOWING PUMP OPERATION



PUMP UNDER TEST



SECTIONAL ELEVATION. SECTION A.A.

PUMP DRIVE ASSEMBLY

developed. Each plunger unit and valve assembly can be quickly and easily removed for inspection and maintenance purposes, and should it be required to alter the capacity of the pumps at any future date, these units can readily be removed and replaced by others.

The driving motor is connected through a flexible coupling to a wormshaft along the side of the pump base, and the crankshaft operating the plungers at the motor end of the unit is driven straight through a wormwheel from the shaft. Phase changing of the plungers to vary output is effected at the opposite end of the pump, where a wormwheel drives the crankshaft through a differential gear assembly to be seen in the drawing on this page. In this assembly the worm shaft *A* drives the wormwheel *B*, which rotates freely on the crankshaft, and is rigidly connected to the left-hand sun wheel *C* of the differential. The planet wheels of the differential are mounted in a carrier *D* and they mesh with a second sun wheel *E* keyed on to the end of the crankshaft. A worm is cut round the circumference of the planet carrier, and it meshes with a wormshaft *F* at the top of the differential box.

It will be appreciated that as the planet carrier is turned through the medium of the worm, the setting of the driven sun wheel is changed in respect to that of the driving sun wheel, and thus rotation of the two crankshafts is moved out of phase. A handwheel is used to turn the wormshaft controlling the planet carrier and the degree of movement is shown by a pointer connected through a small wormwheel to the wormshaft. This pointer moves over a graduated scale, which clearly indicates the volume of liquid delivered by the pump.

The Supply of Insulated Electric Wires and Cables

ON Tuesday, July 2nd, the Monopolies and Restrictive Practices Commission published its *Report on the Supply of Insulated Wires and Cables* (H.M. Stationery Office, price 5s.). The report gives a full survey of the history of the Cable Makers' Association (C.M.A.) and the Covered Conductors Association (C.C.A.) since 1899, when the C.M.A. was formed because production had outrun demand to the extent that price cutting had caused a deterioration in the quality and standard of the products. The members of the C.M.A. were, from an early date, organised in a rubber insulated and mains cable section, and schemes were started for fixing common prices, laying down standards of quality, sharing business in agreed proportions based on sales over previous periods, and, for mains cable, allocating orders and pooling profits. The C.C.A. is concerned with small covered wires, stranded or strip. Twenty-two of the sixty firms in Britain who make insulated electric wires and cables are members of the C.M.A. or of the C.C.A. or both, and seven other firms are associated with members of these associations.

The report states that in 1948 the members of the C.M.A. and C.C.A. together supplied about 76·5 per cent by value of the total output of cables in the U.K.; in 1950 the figure was 76·5.

A summary of the conclusions given in the report is reproduced herewith.

1. The restriction of members' freedom which is involved in their having to submit new designs and types to their associations for approval is a necessary concomitant of the minimum standards of quality established by the associations and has been reasonably administered.

2. A system of purchasing mains and supertension cable which is in the long-term interests both of the consumer and of the producer will have to be worked out by the B.E.A. with the industry. The present arrangement for C.M.A. members' costs to be investigated by independent accountants is in the public interest, and so long as C.M.A. members act together as sellers of these types of cable there should be an obligation on them, in the ranges in which no competition exists, to submit their costs to the B.E.A. in order to establish that the prices charged are reasonable. Prices to buyers other than the B.E.A. should bear a direct relationship to the prices charged to the B.E.A. and this relationship should be reasonable and made known.

3. The system of common prices for rubber cable and the C.C.A. system of common prices for covered conductors should be brought to an end.

4. As a defence against extreme price cutting the C.M.A. and C.C.A. should be allowed to fix minimum prices giving no more than a reasonable profit to the lowest cost producer of each type of cable; if minimum prices are established on this basis, costs and profits should be reviewed by the appropriate Government Department from time to time to ensure that the prices are fixed in accordance with the conditions which we have recommended.

5. So long as there is no independent competition in submarine telegraph cable the periodical cost investigations which are now made are clearly desirable. Submarine telegraph cable is outside the international agreement and it is important that it should remain so.

6. We suggest that the G.P.O. should leave itself free in future to place a proportion of orders for land telephone cable with independent concerns and should take appropriate steps to ensure the protection of the public interest for all its purchases of telephone cable outside the bulk orders. Price agreements for sales of telephone cable to purchasers other than the G.P.O. should be brought to an end.

7. If further bulk orders are placed, their existence should be publicly announced and provision should be made to safeguard the continuance and development of efficient independent competition.

8. The quota systems of the C.C.A. and of the affiliated associations of the C.M.A. should be brought to an end.

9. The system of allocations operated by C.M.A. members and others should be brought to an end in all cases in which it still obtains.

10. The covenant entered into by British Ropes, Ltd., in which they undertake not to make cables, should be allowed to lapse.

11. We welcome the co-operation of the C.M.A. and C.C.A. on the questions of quality clauses in B.S.I. specifications and we recommend that clauses governing the quality of the insulating materials (together with any warning addendum that may be thought appropriate) should be included in all B.S.I. cable specifications.

12. The C.M.A. and C.C.A. policy on patents has been liberal and we have no recommendation to make.

13. When the present arrangements for regulating copper supplies are brought to an end the Government should continue to keep a watch on the position to ensure that supplies are fairly allocated or that competitive supplies are available either within the United Kingdom or by import.

14. We make no recommendations as regards import restrictions, because they form part of a complex whole including provisions affecting the export trade, which are outside our terms of reference.

15. The exclusive-dealing provisions in agreements with wholesalers and other buyers of rubber cable should be brought to an end.

16. The aggregated quantity rebates and association rebates payable in connection with rubber cable and the rebate paid to N.E.C.T.A. on purchases by its members of mains cable should cease.

17. The C.C.A. aggregated quantity rebates and their agreements with buyers who undertake not to make covered conductors should be brought to an end.

A SCOTTISH TRANSMISSION LINE.—A scheme prepared by the North of Scotland Hydro-Electric Board for the transmission of electricity from the transforming station which is to be erected at Fort Augustus to a point in Glen Truim on the existing main transmission lines between Tummel and Keith, has been confirmed by the Secretary of State for Scotland. The scheme will reinforce the Board's grid and will transmit to the grid the electricity which will be produced by the Garry and Moriston generating stations. It is estimated to cost £450,000. The Board's amenity committee, which was consulted about the scheme, recommended adjustments in the proposed route of the line where it passes through the Corrieyairack Pass, and a minor adjustment to avoid woodland near the Glen Truim end of the line. The Board accepted the committee's recommendations; objections were lodged by one body against the scheme and later withdrawn. A White Paper on the scheme has been published and is available from H.M. Stationery Office.

The I.E.E. Summer Meeting

SOME 212 members and guests of the Institution of Electrical Engineers took part in the Institution's summer meeting, which was held, under the presidency of Sir John Hacking, in Dublin from June 25th to 28th. Fine weather contributed much to the success of a busy programme, which included a number of technical visits during the day and social events in the evening.

For those participants who were able to be in Dublin on Tuesday, June 24th, there was an informal reunion and smoking concert at the Metropole Ballroom. During the evening a short lecture was given by Dr. G. Little, of the Old Dublin Society, on the city and something of its historical associations—a foretaste of what lay in store for those members and their ladies who took time off from the technical visits to indulge in the delights of sightseeing.

The meeting proper began on Wednesday morning, June 25th, when members were offered four alternative visits. For the technically minded and conscientious there was the choice of a visit to the Aberdare Electric Company, Ltd., Finglas, where distribution transformers, cables, and thermal storage heaters are manufactured; to the recently commissioned 110kV switching station at Finglas, which supplements Inchinore as a switching station for Dublin; or to the Aer Lingus workshops at Dublin Airport. Finally, for those who preferred to see Dublin, there was a coach tour of the city environs.

The range of cables and conductors produced by the Aberdare Electric Company, Ltd., includes bare aluminium and copper wires and stranded conductors, steel cored aluminium conductors, bronze wires and tinned copper wires, p.v.c. insulated cables for power and communication circuits, and p.b.j. insulated cables. Recently installed wire-drawing machinery and a tinning plant enable the company to produce its own drawn copper wires of which all sizes can be tinned.

In the transformer bay the products, besides small transformers for soil heating and low-voltage lighting, are distribution transformers of 3kVA, 5kVA, 15kVA, 25kVA, and 50kVA ratings. Other sizes from 100kVA to 1000kVA are in production.

The transformers, which are specially designed for rural distribution, have low core losses and magnetising currents and considerable overload capacity. All transformers are double wound, the low-tension side having tappings brought out to four bushings, two of which are in use at a given time, a choice of four voltage ratios, in all, being available. The transformers are mounted in a cylindrical sheet steel tank with an aluminium alloy die cast cover, and brackets are fitted to make the complete single-phase unit suitable for pole mounting. All bushings have twin sheds and the fittings are drilled and tapped for arcing horns.

An interesting product of this company is the "Thermodare" storage heater, which consists, briefly, of heater elements threaded through ducts in the three "bricks" of solid refractory material that comprise the heat storage medium. The whole unit is heat insulated with glass fibre and enclosed in a sheet steel casing, the components of which are clipped together without the use of any conventional fastenings. A time switch connects these heaters to the supply mains at off-peak periods for eight hours, during which the electricity supply authority normally makes energy available at specially low rates.

During the charging period about one-third of the heat input is radiated, the remainder being stored and then dissipated during the sixteen hours discharge period. With a cyclic heat input, therefore, continuous heating is obtained.

On Wednesday afternoon there was a visit to the Dublin Post Office Telephone Exchange and Electricity Supply Board Load Dispatch Equipment. More popular, perhaps, was the alternative visit to the new power station and the brewery of Arthur Guinness, Son and Company, Ltd., at St. James' Gate.

The power station is equipped with three pass-out turbo-alternators, each designed for an output of 1000kW, 0·7 p.f., 3·3kV, three-phase, 50 c/s. The turbine inlet steam conditions are 250 lb per square inch, 555 deg. Fah. At full load the steam consumption is 41,000 lb, including 15,000 lb pass out at 90 lb per square inch, the exhaust pressure being 20 lb per square inch. There are six steam stages and governing is by speed or back pressure. The turbine is geared (4:1 reduction) to a 1500 r.p.m., 1430kVA alternator having 10 per cent reactance.

The boiler-house plant consists of five water-tube units, each with an output of 32,500 lb of steam per hour (economic) and 40,000 lb per hour (maximum), the steam conditions being 265 lb per square inch and 560 deg. Fah. Three of the boilers are equipped with travelling grate stokers for coal firing as well as oil burners for mixed firing. The two remaining units have oil burners only. Unified boiler control is embodied in the steam-raising plant, whereby the fuel feed and draught are regulated in unison by the operation of a single handwheel at each boiler.

On Wednesday evening members and their guests attended the annual conversazione and dance of the Irish Branch of the I.E.E.

Peat Harvesting

The main event on Thursday morning was a visit to the Bord na Mona (Irish Turf Board) Bog at Clonsast, where peat is harvested and dried for transport to the nearby generating station at Portarlington, which is owned and operated by the Electricity Supply Board. The area which is being exploited for peat at Clonsast measures roughly 4 miles by 3 miles and covers 4400 acres. Development of this project, which we propose to describe in a later issue, began in 1936, and at present there are six dredger type excavators in operation, giving an output of 120,000 tons. Clonsast bog is laid out with fourteen cutting trenches, 250 yards apart, the intervening spaces being used as drying grounds. In its present development there are 360 miles of drains, 45 miles of cutting trenches, 32 miles of overhead electric power line, and 16 miles of 3ft gauge railway, which links the bog with Portarlington power station on the one hand, and the main workshop and bulk supply substation, on the other. There are two other substations spaced symmetrically along the "major axis" of the area, alongside the light railway, the 10kV supply being stepped down to 3·3kV for feeding the distribution system for the excavators and loading machines, which are electrically operated. The smaller motors on the excavators and loaders are powered by 400V motors fed from 25kVA transformers on the machines.

On Thursday afternoon, after lunching at Clonsast, the party proceeded in two groups to Allenwood and Portarlington stations respectively.

Allenwood, the newer of these two stations, burns peat produced on the nearby bogs at Timahoe, County Kildare. Each of the four boiler units has a normal output of 125,000 lb of steam per hour (at 425 lb per square inch and 825 deg. Fah.), and the generating plant consists of two 20MW generating sets of normal axial flow design. Work on the station began in February, 1949, and the first generating set was commissioned in January last. The second set is due to be commissioned later this year, and there is provision for a third set to be installed at a later date. Peat, in the form of 10in by 3in by 3in sods, dried by preheated air, is burned on chain-grate stokers, with a normal rating of 125,000 lb per hour, the gross calorific value of the fuel being 6200 B.Th.U. per pound, moisture content 30 per cent, and ash fusion point 1100–1150 deg. Cent. Cooling water requirements for the station are met by a reinforced concrete hyperbolic tower, 286ft high, designed to handle 2,400,000 gallons of water with a temperature range of 82 deg. to 70 deg. Fah. at 75 per cent relative humidity. The generated output is stepped up from 10kV to 110kV for transmission by overhead line to Inchicore and Portlaoghise.

The Portarlington generating station, which was commissioned in 1950, was designed to use the full output of machine harvested peat from the nearby Clonsast bog. The peat has much the same characteristics as that used at Allenwood and the firing arrangements are generally similar. There are three 125,000 lb per hour boilers supplying steam at 425 lb per square inch, 825 deg. Fah., to two radial flow, 3000 r.p.m., 12·5MW turbo-alternator sets. Each generator is connected to a 11/112·3kV transformer feeding an overhead line to Portlaoghise.

For those who preferred sightseeing to the technical visits the day was spent on a tour embracing Enniskerry, Powerscourt and Bray. In the evening there was a reception by the Minister for Posts and Telegraphs at Iveagh House, St. Stephen's Green. In a brief informal speech the Minister welcomed his guests, and Sir John Hacking, in his reply, expressed the thanks of the entire company for the hospitable welcome they had received.

Friday's visit consisted of a coach tour, including Pollaphuca hydro-electric station and Glendalough, County Wicklow, the party being divided, for convenience, into two groups, which completed the circuit in opposite directions.

Pollaphuca is the largest of three generating stations in the River Liffey hydro-electric development. Water is impounded by a mass concrete dam at Pollaphuca, to a level of 615ft O.D., forming a reservoir of 5600 acres. From this reservoir water is conveyed to the power station by a 16ft diameter tunnel, 1230ft long. The two 15MW Kaplan turbo-alternators at Pollaphuca operate under a gross head of 154ft. The discharge feeds a reservoir created by the Golden Falls dam (with its 4000kW power station) about a mile downstream. Leixlip, the third power station, is lower down the river, about 12 miles from Dublin, and the 4000kW Kaplan set operates under a gross head of 57ft, fed from a 100-acre reservoir formed by a dam impounding water to a level of 149ft O.D.

On Friday evening there was a reception and dance at the Metropole Ballroom, at the invitation of the Electricity Supply Board. Saturday morning was reserved for a tour of Dublin city. In the afternoon a party was held at Newman House, St. Stephen's Green, and in the adjoining Iveagh Gardens, when the guests were received by Dr. Michael Tierney, president of University College, Dublin, and Mrs. Tierney.

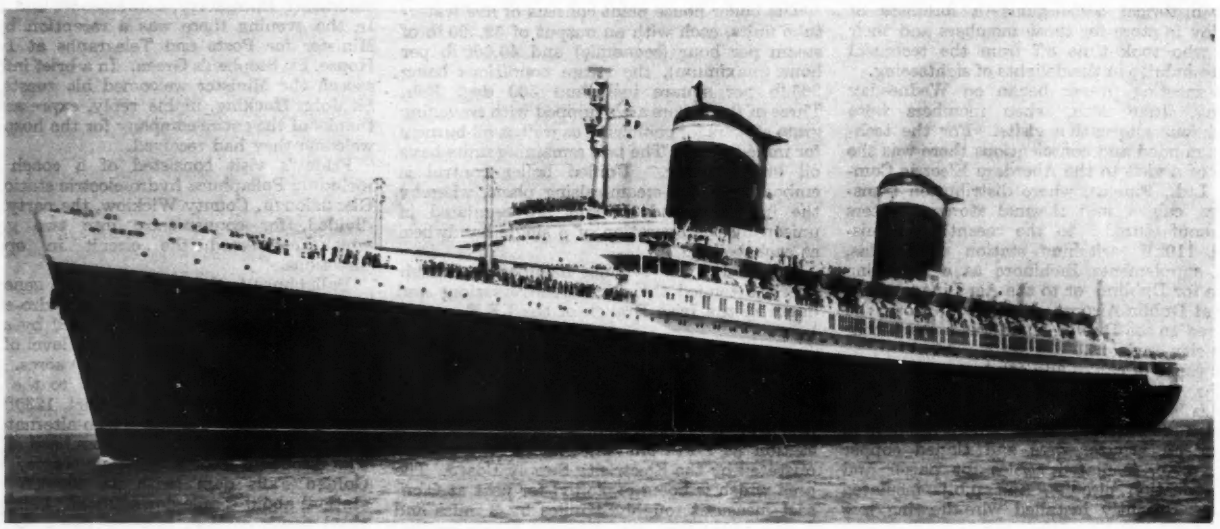
Films on Tubular Steel Construction.—We were recently invited to see two films, which have been made for Stewarts and Lloyds, Ltd., to depict two important works with which that company has recently been concerned. The first was entitled "Steel Pipes for Sindri," and showed the vast amount of pipework necessary for the large fertiliser factory which has recently been erected at Sindri, in Bihar State, India, and is now producing 1000 tons of ammonium sulphate daily. Much of this work was carried out in a new factory in Calcutta, which was erected by Stewarts and Lloyds of India, to handle this contract. The second film showed the construction of the welded tubular steel jib of the W.1400 dragline which is now at work stripping overburden at the Corby ironstone quarries. The jib is 282ft in length, and carries a bucket with a capacity of 20 cubic yards. The special problems in the design and construction of a structure of this magnitude are outlined in the film, which shows the manufacture of the steel, the rolling of the tubes, their fabrication on the site by Tubewrights, Ltd., and finally the completed machine at work. The way in which the design of the jib departs from conventional practice and the particular difficulties which the use of welded tubular members entailed, are described in the film, which runs for thirty-five minutes. Both the factory at Sindri and the W.1400 dragline have been described in some detail in these columns. The films may be obtained on loan from the publicity department of Stewarts and Lloyds, Ltd., Brook House, Upper Brook Street, London, W.1.

The Steamship "United States"

THERE is no doubt that June 10, 1952, will be remembered as an important date in American shipbuilding history; on that day the 53,330-ton S.S. "United States" returned to Newport News, Virginia, from her official ocean trials, proudly displaying a large broom lashed to her masthead—the traditional symbol of a ship that has swept the seas! This 990ft flagship of the United States Lines is the biggest passenger ship ever built in America and the third largest in the world. The exact speed achieved by the vessel has not been revealed, but, according to an official announcement by the U.S. Maritime Administration, during a sustained power run at the rated 158,000 h.p. level, the liner steadily maintained a speed which "considerably exceeded 34 knots." Since plans for the construction of the "United States" were first announced several years ago it has been common knowledge that she was designed not only as the first "super-liner" to fly the American flag, but as that country's contender for honours as the fastest passenger ship in the world. One may safely dismiss certain rumours to the effect that the operators of the vessel had agreed to place a 28-knot ceiling on her speed as a contribution to amity between the United States and Great Britain! In fact, Commodore Manning, the master of the "United States," has now publicly expressed hopes to crack the current 31·69-knot record of the "Queen Mary" on the maiden voyage of the liner from Bishop's Rock to Ambrose Light, weather permitting. Thus, the mythical "Blue Ribbon of the Ocean" would come to the United States for the first time since 1852, when it was held for a brief period by the 2664-ton S.S. "Baltic," which averaged 13 knots!

On June 20th, less than two hours after the official delivery of the vessel to the United States Lines by the American Secretary of Commerce, the White House released to the Press a letter by President Truman to the Attorney-General, ordering him to take the necessary legal action to determine whether the subsidy allowances paid by the U.S. Government in the case of the S.S. "United States" had been excessive and to protect the interests of the Government. This news brought to a head a controversy which has been widely discussed in American shipping circles. Those in favour of the American Government's point of view argue that the United States Lines have purchased a liner worth more than 70,000,000 dollars for a mere 28,087,000 dollars. The opposite camp, siding with the shipping lines, maintain that the U.S. Government has received from the United States Lines a contribution of 28,087,000 dollars for the building of what will be a major troop carrier in times of national emergency! It would have cost about 43,000,000 dollars to build the ship for purely commercial uses in an American yard. The cost of construction in Great Britain would have been about 25,000,000 dollars. The American Government is obliged, under the Merchant Marine Act, to pay a construction subsidy based on the difference between building costs in a domestic and a foreign shipyard, which thus would have amounted to about 18,000,000 dollars had the vessel only been intended as a passenger liner. However, the "United States" was built to the specifications of the U.S. Navy, to facilitate her rapid conversion into a troop carrier. Whenever the choice lay between demands of luxury or defence, defence won. Thus, windows in the cabin class lounge were rejected because of the structural weakening involved. The appearance of the first-class dining saloon has suffered because the Navy demanded additional reinforcing pillars. Due to the Navy ban on all inflammable materials, there are no wooden ornaments or canvas paintings; instead the public rooms have had to be decorated with aluminium and glass sculptures and flame resistant synthetic fabrics. Various decks have been designed with sufficient strength to be able to carry gun platforms. The cost of these defence measures has been put at 27,000,000 dollars, so that the total Government subsidy amounts to about 45,000,000 dollars.

Mr. Lindsay C. Warren, the Controller-General of the United States, now maintains that the Government has paid about 10,000,000 dollars in excess subsidy for the liner. He claims that the original contract between the Government and the U.S. Lines for the construction of the vessel was not a "binding and unavoidable agreement." Mr. John M. Franklin, president of the U.S. Lines, has declared that, while his company welcomed a full investigation of the subsidy and was willing to co-operate with the Government, it refused to agree to the renegotiation of a contract, which it considered binding and fair to both sides. In the interests of the American shipping and shipbuilding industries, it is clearly necessary that a definite decision concerning the entire question of construction subsidies be made soon. Already the argument involves the S.S. "Independence" and S.S. "Constitution" as well as the "United States." While, on the one hand, Congress never envisaged a "give away" programme to build a privately owned merchant navy with public funds, builders and operators of American ships cannot survive without a reasonable subsidy to compensate for the higher costs of American labour.



STEAMSHIP "UNITED STATES" DURING TRIALS

A Pneumatic Power Saw

FOR some years single-operator, power-chain saws, driven by petrol engines and small electric motors, have been made by J. Clubley Armstrong Danarm, of Abford House, Wilton Road, S.W.1, and the company has now introduced a similar machine with compressed air drive.

This new machine, which is illustrated below, is normally fitted with a cutter bar and saw chain giving a cutting width of 23in, and an alternative cutter bar of 16in cutting width is available for lighter work. It is driven by a heavy-duty air motor made by the Consolidated Pneumatic Company, Ltd., and designed to work with an airline pressure of 80/100 lb per square inch. This motor develops 3 h.p. at 6000 r.p.m., and its consumption is about 50 cubic feet per minute at 80 lb. per square inch.

Power is transmitted to the cutter chain through bevel gears giving a 4 to 1 reduction, which gives a fixed sprocket speed of about 1500 r.p.m. Control is through a thumb lever on the back handle of the machine, and chain tension is adjusted by a simple screw arrangement. The tubular handle grip at the front of the saw is used as a lubricating oil reservoir, and air admitted under pressure to this reservoir forces oil on to the saw chain.

A PNEUMATIC POWER SAW

TECHNICAL CONFERENCE.—The second technical conference organised by the La Mont International Association was held in London on June 10th, 11th and 12th. It was attended by representatives of companies building La Mont forced and controlled circulation boilers, and papers dealing with forced circulation boilers were read and discussed.

British Locomotive Performance and Efficiency Tests

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

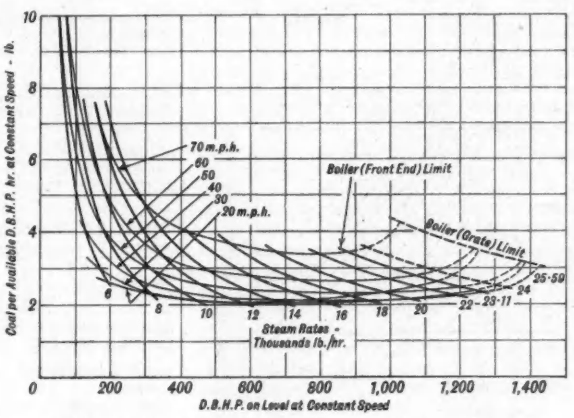
No. III—(*Continued from page 820, June 20th*)

In the previous article on this subject, reviewing the Bulletins 1, 2 *and* 3 *published by the Railway Executive, reference was made to some general characteristics of the locomotives under observation, to the testing procedure, both in the stationary plants and on the road, and details were included of evaporation rates with different classes of coal. In Parts III and IV herewith, details are given of the drawbar characteristics, and of the indicated characteristics where available, and how these results are presented in such a way as to make clear to the operating department the cost, in coal consumption, of running at various speeds with loads covering the normal range of traffic. Coal consumption in both freight and passenger service is given for each locomotive.*

SO that the comprehensive nature of these tests may be fully appreciated a full list is given of the graphs included in the bulletins, though in Bulletin No. 2, dealing with the E. and N.E. "B1" class 4–6–0 engine, those relating to the indicated horsepower are not presented, as circumstances made it necessary to omit indicating. A supplement to Bulletin No. 2 containing this additional data is promised later. From the published graphs and other diagrams, which amount to 146 in all from the three bulletins, a small selection is reproduced herewith. In making this selection it has been thought preferable to confine it to a single range of trials on one engine, so that the manner of presentation can be studied as a consecutive series. From the whole range of tests certain tables of results have been prepared covering all three engines. The complete series of graphs and diagrams in each of the Bulletins 1 and 3 covers the ratios and so on given at the foot of column 3.

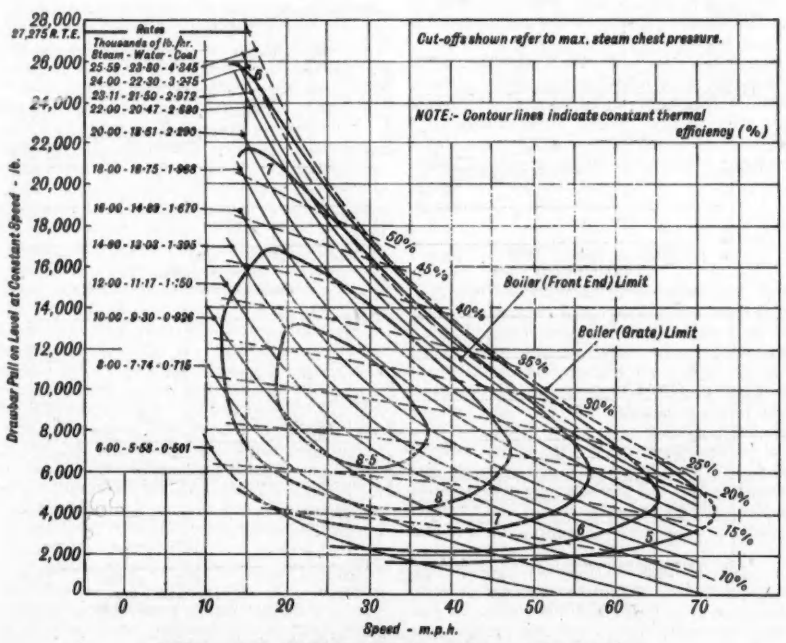
While the published data will be of great interest to engineers, not only in this country, but in many parts of the world, the main purpose of the tests was to provide information for the operating departments so that workings could be devised to make use of the most economical performance range of each locomotive, consistent, of course, with the meeting of traffic requirements. As was explained in the article in THE ENGINEER for April 20, 1951, on the Western Region "Castle" class locomotives, this practice had, to some extent, been followed in the fixing of express passenger train schedules on the Great Western Railway, but the method used, with its possibilities and limitations, would not be familiar to the operating departments of all Regions, and the bulletins explain, in simple terms, how the test results can be applied. The need to reduce coal consumption is so great at the present time that it would be clearly advantageous to examine train loadings and schedules to see whether they fall within the most economical working ranges of the locomotives concerned, and, if not, to see whether adjustments acceptable to the operating department could not be made. The need for accelerated service has also been stressed many times recently in THE ENGINEER. The data from performance and efficiency tests, such as that contained in these bulletins, can be used to determine just where running times may be cut with minimum increase in coal consumption, having due regard to the permanent speed restrictions on various parts of the line which are laid down by the civil engineer.

In Figs. 8 and 10 are reproduced graphs of drawbar pull against speed, and in this one instance curves relating to a second locomotive are shown: the "Hall" fired on Markham coal in Fig. 8, and the "B1" 4–6–0 fired on South Kirkby coal in Fig. 10. The full lines of drawbar pull, each at a constant rate of evaporation, are intersected by dotted lines showing the ranges of cut-off, while contour lines are superimposed upon the diagram showing lines of constant thermal efficiency—on a drawbar horsepower basis. It will be noted that while the maximum thermal efficiency of the two engines, using these two fuels, is much the same, the 8·4 per cent contour for the "B1" extends from 30 to 47 m.p.h., the 8·5 per cent contour for the "Hall" extends from 18 m.p.h. up to 37. This characteristic will be noted in some of the details tabulated subsequently. All the remaining graphs reproduced relate to the "Hall" class engine, and in their manner of presentation they can be taken as typical. Fig. 9 shows the coal consumption plotted against the drawbar horsepower, and it will be seen that in the lower ranges of speed, such as might be expected to prevail with a mixed traffic engine, these curves have a remarkably flat form. Even when the steam rate rises to 22,000 lb per hour the coal consumption per drawbar horsepower-hour is still well below 3 lb at speeds between 20 and 60 m.p.h. As mentioned in the previous article, however, there is a considerable disparity between the performance of this engine on Welsh coal, for which it was designed, and on hard coal of grade 2 quality, and with the latter fuel at 20,000 lb of steam per hour all the coal consumption curves for this engine begin to turn sharply upwards.



Markham coal, 14,330 B.Th.U./lb. Exhaust steam injector

FIG. 9—COAL AND DRAWBAR HORSEPOWER


Rates
Thousands of lb./hr.
Steam - Water - Coal
25·59 - 23·80 - 4·245
24·00 - 22·30 - 3·975
23·11 - 21·50 - 2·972
22·00 - 20·47 - 2·690
20·00 - 18·61 - 2·295
18·00 - 16·75 - 1·968
16·00 - 14·89 - 1·670
14·00 - 13·02 - 1·395
12·00 - 11·17 - 1·150
10·00 - 9·30 - 0·926
8·00 - 7·74 - 0·715
6·00 - 5·58 - 0·501
Cut-offs shown refer to max. steam chest pressure.
NOTE:- Contour lines indicate constant thermal efficiency (%)
Boiler (Front End) Limit
Boiler (Grate) Limit
Drawbar Pull on Level at Constant Speed - lb.
Speed - m.p.h.

Markham coal, 14,330 B.Th.U./lb. Exhaust steam injector

FIG. 8—DRAWBAR CHARACTERISTICS—"HALL" LOCOMOTIVE

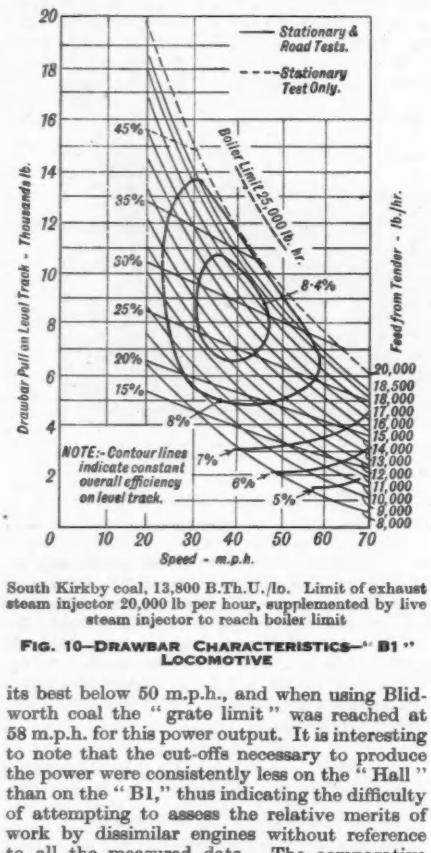
COAL CONSUMPTION

The bulletins become of still more absorbing interest when the scientific test results are

Series of Graphs, &c., given in Bulletins

(*a*) Complete table of valve events.
(*b*) Graphs: drawbar pull on level, speed.
(*c*) Graphs: d.h.p. on level, speed
(*d*) Graphs: water per d.h.p.-hour, d.h.p. on level.
(*e*) Graphs: coal per d.h.p.-hour, d.h.p. on level.
(*f*) Graphs: example of range of economical working (freight) coal per d.h.p.-hour, train load at 40 m.p.h.
(*g*) Graphs: coal per d.h.p.-hour, passenger train load on level.
(*h*) Graphs: coal per ton-mile, passenger train load on level.
(*i*) Graphs: coal per d.h.p.-hour, passenger train load, 1 in 200 rising.
(*j*) Graphs: coal per ton-mile, passenger train load, 1 in 200 rising.
(*k*) Graphs: coal per d.h.p.-hour, freight train load, level.
(*l*) Graphs: coal per ton-mile, freight train load, level.
(*m*) Graphs: coal per d.h.p.-hour, freight train load, 1 in 200 rising.
(*n*) Graphs: coal per ton-mile, freight train load, 1 in 200 rising.
(*o*) Graphs: temperatures: admission steam and saturation temperature related to cylinder feed.
(*p*) Graphs: temperatures: admission steam and mean smokebox related to firing rate.
(*q*) Graphs: evaporation curves.
(*r*) Graphs: draught curves.
(*s*) Graphs: indicated tractive effort, speed.
(*t*) Graphs: indicated horsepower, speed.
(*u*) Graphs: steam and coal per i.h.p.-hour.
(*v*) Graphs: efficiency curves.
(*w*) Graphs: overall efficiency referred to cylinders.
(*x*) Examples of typical indicator cards.

translated into the practical politics of train loading and scheduled speed, and four sets of graphs giving coal consumption per ton-mile are reproduced in Fig. 11; these relate to passenger service on the level, and on a rising gradient of 1 in 200, and freight service in similar road conditions. As before, these graphs display the working of the "Hall" class engine on Markham coal, but results for all three engines on the five varieties of coal used are set out in the accompanying tables. These include figures of coal per ton-mile, which is a primary concern of the operating department, and also coal per drawbar horsepower-hour. A further table has been prepared to show the cost in coal per drawbar horsepower-hour of sustaining 1000 d.h.p. on level track at different speeds and with the different coals. This latter table, more clearly perhaps than any other, shows some of the differences between the "Hall" and the "B1." The working efficiency of the "B1" is excellently sustained throughout the range from 30 m.p.h. to 60 m.p.h., and there is little difference in the performance whether using South Kirkby or Blidworth coal; the "Hall," however, is at



South Kirkby coal, 13,800 B.Th.U./lo. Limit of exhaust steam injector 20,000 lb per hour, supplemented by live steam injector to reach boiler limit

FIG. 10—DRAWBAR CHARACTERISTICS—"B1" LOCOMOTIVE

its best below 50 m.p.h., and when using Blidworth coal the "grate limit" was reached at 58 m.p.h. for this power output. It is interesting to note that the cut-offs necessary to produce the power were consistently less on the "Hall" than on the "B1," thus indicating the difficulty of attempting to assess the relative merits of work by dissimilar engines without reference to all the measured data. The comparative figures go some way to explaining much of the very excellent work that was noted with "B1" engines during the interchange trials of 1948, and the Blidworth coal figures for the "Hall" equally point towards some reasons for the disappointing results obtained on some runs with this class during the same series of trials. No doubt the further bulletin that is promised will go more fully into these most interesting topics.

With the "B1" it will be seen from the coal consumption figures for 1000 d.h.p. that the disparity between "Blidworth" and "South Kirkby" results grew *less* as speed increased, and altogether this class of locomotive emerges from the tests with an impressive record. It would, on the other hand, have been most interesting to observe how this engine behaved with soft Welsh coal. "Blidworth" and "South Kirkby" are medium and first-class varieties of the same general kind of coal, the coal for which the "B1" was expressly designed; whereas in fairness to the "Hall" it must be said that "Markham" and "Blidworth" are dissimilar, and it is only when the power output rises to heights rarely needed in

Coal per Ton-Mile: 4–6–0 Locomotives

Service	Gradient	Load (tons)	Speed (m.p.h.)	"Hall"		"B1"	
				Markham	Blidworth	S. Kirkby	Blidworth
Passenger	Level ...	250	50	0·067	0·08	0·067	0·075
		250	60	0·08	0·095	0·077	0·084
		400	50	0·055	0·063	0·055	0·059
		400	60	0·068	0·085	0·064	0·070
Passenger	1 in 200 rising	250	40	0·133	0·162	0·137	0·148
		250	50	0·150	0·191	0·143	0·157
		400	40	0·120	0·150	0·119	0·129
		400	50	0·148	0·200	0·133	0·140
Freight	Level ...	500	35	0·045	0·058	0·053	0·056
		500	45	0·066	0·080	0·067	0·072
		1000	30	0·038	0·045	0·042	0·045
		1000	40	0·055	0·070	0·054	0·057
Freight	1 in 200 rising	500	25	0·11	0·128	0·123	0·134
		500	35	0·125	0·163	0·127	0·137
		800	20	0·105	0·127	0·127	0·138
		800	30	0·130	—	—	—
		1000	20	0·110	0·145	0·130	0·138

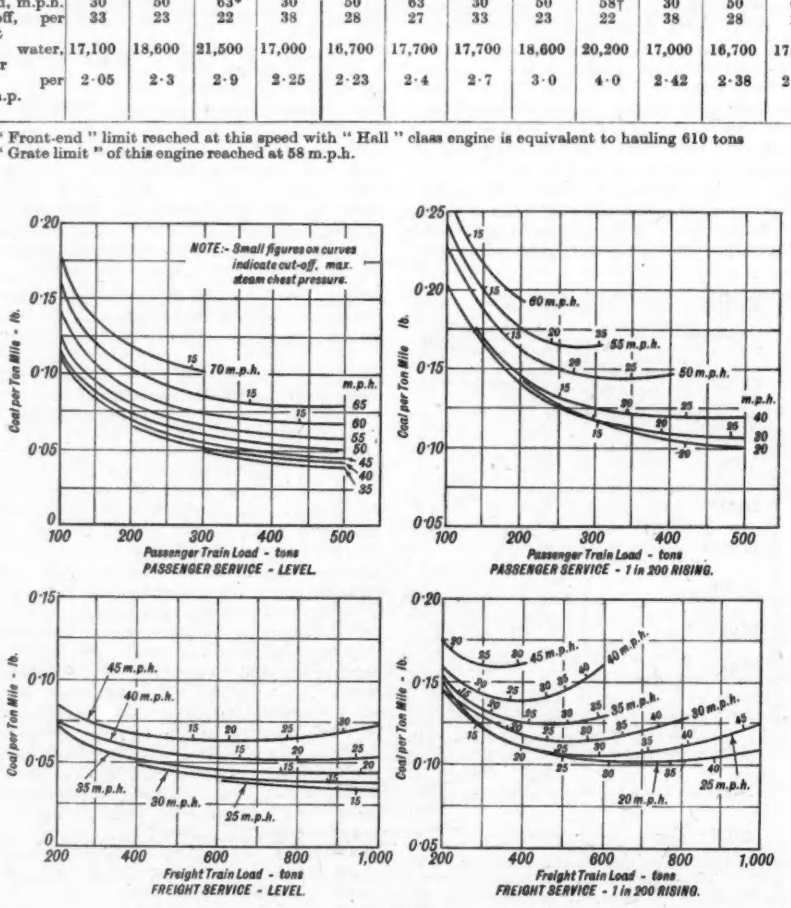
Coal per D.H.P.-Hour: 4–6–0 Locomotive.—On level Track

Service	Load (tons)	Speed (m.p.h.)	Coal per d.h.p.-hour (lb)			
			"Hall"		"B1"	
			Markham	Blidworth	South Kirkby	Blidworth
Passenger	300	60	3·0	3·65	2·86	3·15
	300	70	3·4	4·4	2·8	3·1
	400	55	2·65	3·25	2·65	2·88
	400	65	2·95	3·88	2·6	2·8
Freight	500	35	2·25	2·65	2·48	2·67
	500	45	2·20	2·65	2·27	2·46
	1000	30	2·05	2·50	2·23	2·43
	1000	40	2·15	2·75	2·18	2·35

Development of 1000 D.H.P. on Level Track

Engine... ...	"Hall"			"B1"			"Hall"			"B1"		
Coal	Markham			South Kirkby			Blidworth			Blidworth		
Speed, m.p.h.	30	50	63*	30	50	63	30	50	58†	30	50	60
Cut-off, per cent	33	23	22	38	28	27	33	23	22	38	28	27
Feed water, lb/hr	17,100	18,600	21,500	17,000	16,700	17,700	17,700	18,600	20,200	17,000	16,700	17,400
Coal per d.h.p.	2·05	2·3	2·9	2·25	2·23	2·4	2·7	3·0	4·0	2·42	2·38	2·48

* "Front-end" limit reached at this speed with "Hall" class engine is equivalent to hauling 610 tons
† "Grate limit" of this engine reached at 58 m.p.h.


NOTE:- Small figures on curves indicate cut-off, max. steam chest pressure.
Coal per Ton Mile - lb.
Passenger Train Load - tons
PASSENGER SERVICE - LEVEL.
PASSENGER SERVICE - 1 in 200 RISING.
Freight Train Load - tons
FREIGHT SERVICE - LEVEL.
FREIGHT SERVICE - 1 in 200 RISING.

Markham coal, 14,330 B.Th.U./lb. Exhaust steam injector

FIG. 11—EXAMPLES OF COST IN COAL OF DIFFERENT TRAIN LOADS AND SPEEDS

Class "5" mixed-traffic service that the coal consumption curve on "Blidworth" begins to rise so steeply. We are, too, comparing the finer points of performance. Locomotives that will develop 1000 d.h.p. at 50 m.p.h. on less than 2·5 lb of coal per drawbar horsepower-hour stand in the very front rank. In THE ENGINEER for November 4, 1949, details were given of some hard running in Cornwall with a "Hall" class engine, on cut-offs between 35 per cent and 45 per cent, at speeds of about 30 m.p.h. Reference to graphs in Bulletin No. 1 shows that in such conditions, when outwardly there was ample evidence of hard slogging, the thermodynamic performance was highly efficient, with a coal consumption of not more than 2·2 lb per drawbar horsepower-hour.

(To be continued)

A Worcester Company's Golden Jubilee

THE industrial expansion and development in Great Britain during the nineteenth century is reflected in the twentieth century by the number of occasions upon which centenaries or other anniversaries are celebrated. This year the firm of Heenan and Froude, Ltd., of Worcester, celebrates the golden jubilee of its incorporation under the present style and title. In recent years the company has followed a policy of expansion and a number of well-established firms have been acquired by purchase to form what is known as the Heenan and Froude group. To mark the occasion of the jubilee, an illustrated brochure setting forth, in brief, the history of the associated companies has been produced, and representatives of the technical press were recently the guests of the group and made a tour of inspection of the works of Heenan and Froude, Ltd., at Worcester, and the Gloucester establishment of Fielding and Platt, Ltd.

Although registered as an incorporated company on March 29, 1902, the company had its beginnings over twenty years earlier, when Mr. Hammersley Heenan, after service as an engineer in the East Indian Railway and the Public Works Department in India, returned to England in 1880. He purchased the steel works of Woodhouse and Co., Manchester, and one year later the firm of Heenan and Froude was founded, when Mr. R. H. Froude, who was associated with Mr. Heenan in India, was taken into partnership. Mr. Froude was the eldest son of William Froude, F.R.S., whose name is so closely linked with the methods of estimating the horsepower of ships' machinery from the resistance measured from the testing of scale models in a tank, and whose work is commemorated by the William Froude tank at Teddington. The son brought to the firm the hydraulic dynamometer, invented by William Froude for his work at the Admiralty.

Business expanded and additional premises were acquired, but they proved inadequate, and a move was made to Worcester in 1903, the Manchester plant being retained as a constructional steel works until 1935. The original Worcester premises were constructed in 1866 as a locomotive works and since 1937 have been extended on three occasions so that the plant now covers 8 acres and employs 1100 people.

During its early years the firm specialised in steel structural work, an example being the Blackpool Tower, but the Froude dynamometer soon became the main product, to which was added water coolers, air filters, and air coolers. The years between the world wars saw the beginning of other special machines being added to the firm's products, including automatic machines for the chain industry and for the forming of wire and strip and the production of "dynamatic" and electric dynamometers and "dynamatic" controlled slip couplings.

Before the second world war the formation of the Heenan and Froude group of companies was initiated with the purchase in 1936 of the Court Works, Ltd., malleable and grey iron-founders, and this was followed by the acquisition of Fielding and Platt, Ltd., engineers, of Gloucester. Since the war several more firms have been added to the group, including Industrial Waste Eliminators, Ltd., and the New Destructor Company, Ltd., founded in 1887, the acquisition of which has widened the field of application of the holding company's refuse disposal plants. W. G. Bagnall, Ltd., the locomotive builders and railway engineers, became a member of the group in 1947, as did two more companies in 1949, namely, the Morton Machine Company, Ltd., the makers of mixing machinery; and Associated Locomotive Equipment, Ltd., a design and research organisation, its products being manufactured at the works of Heenan and Froude, Ltd. Each firm remains a separate entity and continues to specialise in its own production and to undertake its own responsibilities while making available its resources, knowledge and experience to the group as a whole.

The representatives of the technical press were received by the Mayor of Worcester on their arrival and after lunch, taken in the ancient Guildhall. They made a tour of the works of Heenan and Froude, Ltd., to see the general layout and equipment of the factory and also something of the diverse range of products currently passing through the shops. Later the party proceeded to Gloucester, where they were welcomed by Mr. F. James Fielding, the managing director of Fielding and Platt, Ltd., who is also the managing director of Heenan and Froude, Ltd., and afterwards entertained to dinner.

Mr. Samuel Fielding and Mr. James Platt founded the company in 1866 as a general engineering business, which actively pioneered in hydraulic engineering to produce presses, pumps and accumulators. Early in the present century the company commenced to produce gas engines, which eventually developed into a range of oil engines and which are now manufactured by Petters, Ltd., and known as Petter-Fielding diesel engines.

After the first world war the range of the company's products expanded to include equipment for shipyards and presses for the forging and the manipulation of metal and also for plywood and concrete. Extrusion presses for the production of light alloy components were made during the second world war and other developments included the construction of high-speed variable delivery pumps.

Since it was founded eighty-six years ago the company has expanded the original small workshop to a factory covering an area of 3½ acres, employing 650 people and producing a wide variety of presses for extrusions, flanging, deep drawing, stretching, scrap metal baling, briquetting, and tiling.

In the works at Worcester and Gloucester the individual character of the products of the two companies was emphasised by the absence of long assembly lines which are associated with mass production. Another item in common is the comprehensive apprenticeship scheme, including the craft school, which gives training to boys entering the industry and provides a steady flow of trained engineers for appointments throughout the works.

A Lighter Factory

A NEW factory has been opened at Leatherhead by Ronson Products, Ltd., the well-known firm of lighter manufacturers. This firm moved to Leatherhead in 1940, when it acquired a large house and laid down repair shops in a number of huts in the adjoining grounds. During the war years the majority of the staff and all of the plant were switched over to the production of armament components, and, at the same time, a certain amount of lighter repair work was carried on. After the war it was decided to manufacture all-British lighters, and within a short while all the plant was tooled up for this work.

Once full-scale production of lighters was obtained it became evident that demands could not be met with the existing accommodation and immediate steps were taken to seek new premises. Land was acquired in Randalls Road, near Leatherhead station, and a new factory, which with offices covers an area of some 41,500 square feet, was built. The new establishment consists of an attractive modern two-storey office block in front of a single-storey workshop contained in three long bays and subdivided into production areas.

The many problems which were encountered in arranging the economical and even flow of work will be appreciated when it is pointed out that the firm makes twenty different models of lighters in no less than eighty different finishes. About half of the models are made in large numbers, whilst the others, made in batches, have to be interspersed with the main production flow. Many special machines have been developed for the production of parts standard to various models and for assembling the lighters themselves, and although several types are always in course of manufacture in every department a smooth flow of production is maintained.

In the works the production areas run transversely across the bays and are separated by glazed partitions. At the ingoing end of the works a large well-equipped toolroom has been laid down to supply all the tools, jigs, fixtures, &c., required in the production shops. Components made in an auto-shop next to the toolroom and an adjoining press shop are passed in batches straight into the assembly departments. In these assembly departments the long-run work is generally carried out by hands sitting at stations on each side of a moving belt conveyor. Smaller and individual batches of other lighter models are assembled on benches set apart from the main lines. As each operation in assembly is completed, a complete or percentage inspection is carried out according to the size of the batch. Inspection is very thorough, particularly on checking such things as soldering, where every lighter is tested under water with air at a pressure of 30 lb per square inch to ensure there is no leakage when the lighter is filled with fuel. A number of special machines have been installed for the making, cutting and heat-treating of flint wheels, for induction continuous batch soldering, &c. The lighters when completed are inspected for finish, operation, &c., and placed on a moving belt which conveys them to a packing station.

Throughout the new factory every effort has been made to combine a free production flow with good working conditions. All parts of the factory have good natural lighting, with clean atmospheric conditions, and a heating system is supplied by hot water from an adjoining boiler-house.

A Welded Railway Bridge in Switzerland

A BRIDGE of welded steel construction has recently been erected in Switzerland. The new structure, which is known as the Tannwald Bridge, replaces an iron arched bridge built about a century ago. The new Tannwald Bridge is situated on the Olten-Basle line and crosses the Aar River at Olten. The contract for it was let to the constructional firm, Wartmann and Co., of Brougg.

The bridge (of which at present only the downstream track portion is completed) consists of three plate girder spans, each 118ft long. There are two main girders in each span assembled by arc welding. The wind-bracing is formed by transverse lattice trusses spaced at 19ft 6in centres. The main girders, which carry the dead weight of the steel superstructure and the reinforced concrete decking, are designed to react with this decking under the loads of the trains, ballast and tracks. The main girders consist of a web 8ft 6in deep and ½in thick at midspan and 1in thick near the supports, and two flanges. The flanges are 1ft 6in wide, with corresponding thicknesses ranging between 0·55in and 0·79in for the upper flange and 1·33in and 2½in for the lower flange. Laboratory tests were carried out to study the weldability of the steel. The Tannwald Bridge, which is built for the Swiss Federal Railways, is at present the largest welded railway bridge in Switzerland.

Indian Engineering News

(By an Indian Correspondent)

The Wayward Hooghly and the Port of Calcutta

The River Hooghly is formed by the confluence of the Bhagirathi and Bhairab Jalangi, two spill channels from the Ganga (Ganges), at Nabadwip, about 78 miles above Calcutta. Lower down, i.e., about 42 miles above Calcutta, the Matabhanga-Churni, another spill channel from the Ganga, meets the Hooghly. These three spill channels of the Ganga are known as the Nadia Rivers. The Bhagirathi is the most important of these three as besides being a spill channel from the Ganga, it receives water supply from its four tributaries, all having their origin in the Santal Parganas. About 30 miles below Calcutta the Damodar and the Rupnarain flow in on the right bank and the Hooghly, due to the influence of the latter, takes a right angular bend toward Diamond Harbour at Hooghly Point. Below Diamond Harbour the Hooghly commences to fan out and the width of the estuary at Sangor, 80 miles below Calcutta, is 12 miles. All these tributaries with their spasmodic discharges both in time and volume, subject the Hooghly to meanderings with unhappy results on its navigability. However, this waywardness is not of recent origin and a note on the past attempts at its control may not be out of place in this account.

In 1853 the Bengal Chamber of Commerce addressed the Government of Bengal on "the difficult and dangerous state of navigation of the Hooghly, which threatened at no distant period to render access to the port of Calcutta altogether impracticable for any vessels but those of the smallest tonnage" (the largest vessels visiting the port were then about 1800 tons). As a result of this representation, the Hooghly Commission of 1853–54, comprising three members, was appointed to investigate the matter. Two of the members of the Commission, while deploring the deficiency of charts and documents found it "very difficult to understand how a river like the Hooghly can do otherwise than deteriorate, however gradual or slow the process may be," and accordingly recommended that "it may be well not to lose sight of Malta as an auxiliary port." The third member, Mr. H. Piddington, differed from his colleagues on the question of deterioration and arrived at a more optimistic conclusion as follows: ". . . And I fully concur in the view already taken by so many of the best informed of the witnesses that as one channel shuts up another opens out, which I think is amply borne out by the evidence, so that I find nothing to lead us to anticipate any future deterioration beyond such as may arise from a temporary shallowing of some of the difficult channels while a change is going on near it, as exemplified annually in the alternate closings and openings of the Eastern and Western Guts of James and Mary."

Another critical phase in the channels in the lower reaches occasioned alarm in 1863 and it was proclaimed in London that the trade of Europe with Bengal was in danger of immediate and prolonged suspension. The statement went on to say that "the calamity which has overhung the city for years which Lord Dalhousie strove in vain to avert and the fear of which has at intervals strained and baffled the ingenuity of half the engineers of Bengal, is officially admitted to be at hand." As a result of these forebodings, Mr. H. Leonard was placed on special duty by the Secretary of State for India and in his report of 1864–65, he came to the conclusion that the Hooghly must deteriorate, however slowly, considering the agencies at work on the river, and suggested river training works. During this period, no less than five experts were consulted but none of their somewhat divergent recommendations was implemented except Leonard's spurs at Moyapur, which were constructed in 1870 but removed in 1872 on the recommendation of Mr. G. Robertson, who believed that they had caused more harm than good. With the improvement of the channels due to natural causes, alarm regarding deterioration was allayed until 1891, but in succeeding years successive high freshets caused deterioration of the Ninian Channel, which led to a representation from the Liners' Conference and the Bengal Chamber of Commerce, as a result of which the Commissioners obtained the services of Mr. L. F. Vernon Harcourt, an authority on river engineering. His conclusions, based on all the evidence then available, were distinctly optimistic, his view being that "the Hooghly with the exception of James and Mary Reach and Moyapur affords no indication either in its river portion, its estuary or outlets, of progressive deterioration rendering it necessary to contemplate its abandonment as the navigable outlet of the trade of Calcutta. . . ." He added that "provided these two obstructions can be removed and some improvements effected in the estuary, the Hooghly will provide in the future a considerably better waterway between Calcutta and the sea than it has done in the past," and suggested the execution of certain river training works and the improvement of the channels by means of a powerful suction dredger.

Dredging was commenced in 1907 as a result of which abnormal seasonal deterioration at critical points was checked. Various committees were constituted by the Government of Bengal and the port authorities after this date. Acting on the report of Major Hirst, the Stevenson Moore Committee of 1916 undertook the closest and most complete technical examination, the hydraulic aspect of which was comprehensively surveyed by Mr. H. G. Reake, River Surveyor. A further report was again written by Mr. T. M. Oag in 1938 but none of the reports up to that date appear to disclose any indication of any serious deterioration of the river to justify alarm.

The suggestion to by-pass the difficult stretch of the river between Calcutta and Diamond Harbour by the construction of a ship canal was referred to Sir Claude Inglis in 1947. There is nothing in the Inglis report to suggest that a crisis is in the offing and his recommendation that model experiments should be conducted has been accepted and implemented by the Commissioners.

Numerous and variable factors such as the seasons and the melting of snows on the Himalayas, the rainfall in the Gangetic Delta, the alignment of the main stream of the Ganga in relation to the offtakes of the feeder rivers, the periodical shifting of the sites of those offtakes, the alterations in the beds of the Ganga and the feeder rivers, the effects of the supplies of water carrying coarser sand received from time to time from the western tributaries, the hydraulic balance between the Hooghly and the Damodar and the tidal influx from the sea on which the river has to depend for a major portion of the year, all these factors make it impossible to predict the behaviour of an estuarian river like the Hooghly except by an empirical process of careful experiments with models. Two models have been constructed at the Central Water and Power Research Station, Poona. Model I covers about 130 miles of the river and its scales are, respectively, horizontal 1 : 2000 and vertical 1 : 160. This model is being used to study flow conditions up to its upper limit and the feasibility of training measures up to Moyapur. Model II with horizontal and vertical scales of 1 : 300 and 1 : 60, respectively, is being used to study in detail the various problems in the port area from Moyapur to Konnagar. Both are tidal models with mobile bed and Model I is believed to be the biggest of its type in the world. The experiments at Poona have not progressed sufficiently long to yield any firm conclusions but there are hopeful indications of fruitful results. (It is hoped to give them in these notes in due course.) Meanwhile, every effort is being made to achieve the target of a minimum draft of 26ft throughout the year by means of intensified dredging.

Acknowledgments are due to Mr. N. M. Ayyar, the chairman, whose report to the Commissioners of Port of Calcutta and Government of India forms the basis of these notes; to the Editor, the Port Engineer, Calcutta, and to the Director, Central Water and Power Research Station, Poona, for the information about the models.

Koyna River Basin

Out of the total of 1,537,000kW power generated in India, 938,000kW is generated by thermal stations and 599,000kW by utilising the natural water resources. Out of the latter, 50 per cent is generated near Bombay. Recently, however, owing to the failure of rains near this area, shortage of power has led to severe rationing restrictions, thus upsetting the balance of textile and other industries in Bombay. Consequently, attention is now focussed on the Koyna hydro-electric scheme, which had not previously been included in the draft five-year plan, but may now qualify for inclusion in the revised plan to be published next month.

The Koyna River, which rises on the western slopes of the Mahabaleshwar Plateau in the Western Ghats of the Bombay State, offers one of the most suitable sites available for development of cheap hydro-electric power and for providing storage for irrigation. Located north-south, the eastern foot of the Ghats is at an elevation of 1900ft to 2000ft above mean sea level; the area for miles to the west of the Ghats forms the Deccan plateau at an elevation of about 1800ft. The western face of the Ghats has steep slopes, ending at a ground level of about 500ft; this drop of about 1500ft between the two sides of the Ghats and a catchment of 346 square miles receiving an average annual rainfall of over 200in, makes a hydro-electric scheme possible at a comparatively moderate cost.

The firm of Tatas, pioneers of hydro power projects in India, undertook the first investigations of this scheme in the years 1920–25. After an attempt in 1938 given up on the outbreak of war, the Government of Bombay established a grid department to investigate the possibilities of increasing power supply in the State of Bombay and Koyna came under detailed investigation. The project, which is expected to generate 498,000kW in its final stage (load factor 66 per cent), more than the entire power from Damodar Valley Project, has been held up for want of capital, but may now go ahead under the auspices of Colombo plan.

The storage will be obtained by a concrete and stone masonry dam of about 226ft maximum height above river bed in the first stage and 269ft in the second. The length is about 1100 yards. Water from the reservoir would be delivered through a concrete-lined tunnel, 12,000ft in length and some 24ft in diameter, into a power station at the foot of the hill by means of penstocks. The intake into the diversion tunnel would be 6½ miles upstream of the dam. In the first stage of the project 67,500 million cubic feet of storage would be utilised for generating 360,000kW firm power with an installed capacity of 420,000kW. In the second stage an additional storage of 44,100 million cubic feet would be utilised.

The cost of civil engineering works is estimated at Rs. 30 crores, the dam alone accounting for Rs. 17 crores. The electrical works, including transmission at 220kV over two single-circuit lines, each about 145 miles long, is estimated to cost another Rs. 30 crores. With an average bulk supply rate of 0·35 of one anna per kilowatt-hour (16 annas equals 1 rupee) the scheme is expected to show profit from the third year of its operation and yield a return of about 5½ per cent on the invested capital from about the ninth year of service.

The basin is rich in deposits of bauxite and manganese and iron ore. A few heavy industries have recently sprung up in the area, which has great industrial possibilities. Koyna has fired the imagination of people in the Deccan to such an extent that the question of its inclusion in the five-year plan is reported to have played a great part in the recent general election. The report of the Government Planning Commission, some of whose members have recently visited the site and have been waited upon by a delegation of the Deccan Manufacturers' Association, is awaited with great interest.

Industrial and Labour Notes

Wage Claims

At the end of last week there was presented to the Engineering and Allied Employers' National Federation a claim for an increase of £2 a week in the wages of workers in the engineering industry. The claim was put forward by the Confederation of Shipbuilding and Engineering Unions, which had originally suggested that an increase be asked for, without specifying the actual amount.

At the recent annual meeting of the national committee of the Amalgamated Engineering Union, however, a resolution was carried in favour of applying for a £2 a week increase, a resolution which did not have the full support of the A.E.U. executive or of the Confederation. But when the Confederation met prior to submitting the claim last week the decision was taken in favour of asking for £2 a week. The Confederation also presented a claim to the Shipbuilding Employers' Federation, but in this case the £2 a week increase was not mentioned. The employers' federations, in both cases, undertook to consider the claims and to announce their decisions at subsequent meetings.

Another wage claim presented last week was that put forward by the National Union of Mineworkers to the National Coal Board. That claim is for an increase of 30s. a week in the wages of adult workers in the coal mines, with corresponding increases for youths. It has been stated that about 700,000 mineworkers are involved in the claim, which, if granted, would cost the National Coal Board approximately £50,000,000 a year.

Changes in Wage Rates

The Ministry of Labour has announced that changes in wage rates which were reported as coming into operation during May resulted in an aggregate increase of approximately £132,000 in the weekly full-time wages of 400,000 workers. Among those who received increases were those employed in the brick-making industry and in roadstone quarrying, and juvenile workers in the shipbuilding and ship-repairing industry. In this last-named group the increases ranged from 6s. to 11s. a week according to age or year of apprenticeship.

In the first five completed months of this year the changes in wage rates coming into operation meant an aggregate increase of about £1,795,000 in the weekly full-time wages of 4,509,500 workers. That total included £181,400 to 409,000 workers engaged in the industries classified by the Ministry as "engineering, shipbuilding and electrical goods." Last year, in the comparable period, there was a net increase of £2,562,000 in the weekly full-time wages of 6,485,000 workers. The changes reported in May had the effect of increasing the index of rates of wages (June, 1947=100) by one point. At the end of May the index stood at 129 for all workers, compared with 126 at the end of last year.

European Steel Production

The United Nations Economic Commission for Europe has published this week its *Quarterly Bulletin of Steel Statistics*, in which it is estimated that, during the first quarter of this year crude steel production in Europe was running at an annual rate of 72,892,000 metric tons. The bulletin says that production in the whole of 1951 is estimated to have totalled 67,623,000 metric tons. The information on which this year's first quarter figure is based does not take into account steel production in Russia, though the Economic Commission for Europe has suggested that steel output in that country last year amounted to 31,300,000 tons. For the purposes of comparison, the crude steel production of the U.S.A. has been included in the tables published in the bulletin. During the first quarter of this year it was at an annual rate of 98,692,000 tons, compared with 95,377,000 metric tons in 1951.

The tables presented in the bulletin summarise the European production of raw materials and of finished steel, and give also the European consumption, exports and imports of raw materials. Tables which are included for the first time, show the extent of the foreign trade of European countries in rolled steel products and the production and exports of iron ore, manganese ore and scrap by certain overseas countries which are sources of supply for Europe. This information on the resources of overseas countries underlines the importance of Africa as a source of Europe's steel-making materials. The bulletin, which is printed in English and French, is obtainable at H.M. Stationery Office, price 3s. 9d.

The Steel Scrap Drive

In a written reply to a Parliamentary question on home supplies of iron and steel scrap, the Minister of Supply, Mr. Duncan Sandys, has stated that he has recently examined, with the scrap drive organisation, methods of intensifying further the efforts to collect more ferrous scrap. The reply mentioned the personal letter sent last week by the Minister to the managing directors of about 13,000 steel-using firms, urging that any obsolete machinery or unwanted ferrous metal should be turned out for scrap as quickly as possible. It also stated that the National Farmers Union had devised a special scheme to encourage farmers to turn out scrap metal, under which farmers were to be paid £3 a ton for their scrap, free of transport costs. Local authorities throughout the country were also helping by organising civic scrap drives and the scrap drive organisation was offering financial assistance for the recovery of disused tram rails as well as tins or other metal from domestic refuse.

The Minister's reply added that, within the spheres for which they were responsible, valuable assistance was being received from Government departments, the three Services and public bodies such as the British Transport Commission and the National Coal Board. But in order to make sure that all remaining scrap was collected from Government establishments, the Minister said that he was arranging in appropriate cases for a joint inspection to be made of the department concerned by representatives of the Ministry of Supply and the scrap drive organisation. The first of those inspections would be carried out shortly at Woolwich Arsenal. Efforts were also being made to speed up the clearing of old defence works. By means of those and other measures, the reply concluded, it was believed that all possible action was being taken to accelerate the collection of scrap metal for steel making. But, the Minister observed, the results would still continue to depend upon the response of those who held the scrap.

Financing Industry

Speaking in Leicester on Wednesday of last week, Sir Archibald Forbes, president of the Federation of British Industries, said that anxiety about the future financing of industry had come at a time when the foremost need was to redress the adverse balance of payments, the remedy for which depended so much upon greater efficiency and greater production. This country's competitive ability was determined by the cost of production, which in turn rested not only upon effort and management but on the employment of the most modern equipment. The creation of new markets was also needed by launching out into new ventures. If, Sir Archibald emphasised, there was a running down of the efficiency of equipment or a lessening of risk taking through lack of capital or discouragement of enterprise, competitive ability was bound to be lowered. Successive Governments, he commented, appeared to be oblivious of the inevitable consequences of raiding the resources upon which industry depended for its maintenance and development.

Sir Archibald went on to say that it would be unfair to allow criticism of the taxation of industrial profits to cloud a view of the Government's economic policy as a whole. He considered that there was much to welcome in the initial approach to the grave problem of the national finances which indicated a determination to face realities and to take steps, however drastic and unpalatable, to protect the currency and to achieve solvency. The introduction of a strong monetary policy had brought results in a comparatively short time and although it might have created credit difficulties in certain directions, it had been justified by its overall deflationary influence. The movement towards a reduction in Government expenditure in the way of subsidies and to some extent in administration was refreshing as representing a turning away from the policy since the war of ever-mounting expenditure on Government account.

But, Sir Archibald continued, while the alarming drain on the reserves of gold and foreign currency had been substantially arrested, it had not yet been stopped and the country's reserves were now at a precariously low level. The field for any further restriction of imports was not great if our scale of trading and of diet was not to be reduced. The cuts in imports which had to be made had already had their repercussions, and dependent as this country was on world trade, it was imperative that it should find other means of balancing the overseas account. That, of course, could only be done by increasing exports. It represented a crucial problem, but was one which would have to be solved, even if it entailed further diversion of supplies from consumption at home. Success, Sir Archibald said, would not be achieved without the lowering of the cost of production by greater effort and efficiency and by determined and skilful salesmanship, an art which he thought in some instances had suffered through the prolonged existence of a sellers' market. Nevertheless, all the determination and ingenuity on the part of industry would not of itself achieve the desired result if our goods were barred from overseas markets by prohibitions, restrictions or unreasonable tariffs, and it was in this, Sir Archibald suggested, that Government help must be relied upon in an effort to bring about the greatest practicable degree of liberalisation of trade.

Aluminium and Tungsten Prices

The Ministry of Materials has announced that as from July 1st the price of virgin aluminium in ingot form has been increased from £154 to £157 per long ton, delivered into consumers' works. For metal in notch bar form the addition of £2 10s. a ton remains unchanged. The new price applies to metal of a purity of 99 per cent to 99·5 per cent inclusive, the premiums payable per ton for higher purity ingot having been increased as follows: minimum purity, 99·6 per cent, £2 2s.; 99·7 per cent purity, £4 4s.; and 99·8 per cent purity, £8 8s.

The Ministry has also stated that, as from June 26th, its selling price for tungsten ore of standard 65 per cent grade and ordinary quality has been reduced from £25 to £23 7s. 6d. per long ton, delivered consumers' works. The current buying price is £22 5s. per long ton, c.i.f. It is stated that the difference between the buying and selling prices is accounted for by the cost of freight, storage, handling and agents' commissions, and by the provision which it has been necessary to make for the liabilities which the Ministry has assumed as a result of the policy of forward buying to assure supplies of tungsten ores to British industry.

Notes and Memoranda

Rail and Road

DIESEL ENGINES FOR BRITISH RAILWAYS.—Orders for six diesel mechanical shunting locomotives for use in the Eastern Region have been placed by British Railways. These are the first orders placed in connection with the programme for 141 similar engines, which were authorised, together with 432 diesel-electric engines, for construction during the five-year period 1953–7. The orders placed include three 150 h.p. locomotives of the 0–4–0 type, to be built by the Hunslet Engine Company, Ltd., for use at Ipswich Quay, and three 200 h.p. locomotives of the 0–6–0 type, to be built by the Drewry Car Company, Ltd., for use at Wisbech.

Air and Water

MAIL STEAMER SERVICE.—The Northern Ireland Minister of Commerce states that representatives of the Railways Executive of the British Transport Commission have been examining proposals for improving shipping services between Northern Ireland and Great Britain. These included improvements of ports, additional ships and the transfer from Larne to Belfast of the Northern Ireland terminal of the present service from Stranraer.

SALVAGE OF FLOATING DOCK.—The Admiralty Salvage Organisation is attempting to raise the Admiralty Floating Dock No. 9, of 50,000 tons lifting capacity, sunk at Singapore during the war, on behalf of the British Iron and Steel Corporation (Salvage), Ltd. To assist in the operations the Royal Fleet Auxiliary "Salvictor" has arrived from Portsmouth and the Admiralty Chief Salvage Officer, Mr. C. L. Black, O.B.E., will direct planning and initial organisation.

Miscellanea

PUBLIC HEALTH ENGINEERING.—Engineers from eleven countries are taking part in a course arranged by the British Council in co-operation with the Institution of Civil Engineers on "Engineering Aspects of Public Health," which is being held in London and Birmingham from June 30th to July 12th.

GAS TURBINE APPRENTICE COURSE.—The special course for Ministry of Supply apprentices at the School of Gas Turbine Technology has now been accorded formal recognition by the Ministry of Education and the Institution of Mechanical Engineers. As a result, all the apprentices on the course holding Higher National Certificates have now had them endorsed in Gas Turbine Technology.

LUBRICATING OIL PLANT.—On June 18th Dr. Santiago Vera Izquierdo, Venezuelan Minister of Mines and Hydrocarbons, officially opened the new lubricating oil plant of the Shell Petroleum Company, Ltd., at the Cardon refinery in Venezuela. The plant, which has cost £8,000,000, has an annual output of 100,000 tons and provision has been made to expand the annual capacity of the Cardon refinery from 5 millions to 8½ million tons of crude oil.

BUILDING EXHIBITION.—An exhibition organised by the Ministry of Works and entitled "Building Research and Housing Exhibition," is being held at the Building Centre, Store Street, Tottenham Court Road, London, W.C.1, from July 3rd to July 26th. Its purpose is to show how the results of scientific research can be applied to the building of traditional and non-traditional houses, to increase productivity and lower costs without impairing comfort and convenience.

EXPORTS OF ALUMINIUM MANUFACTURES.—The Board of Trade has announced that from July 1st the price per ton below which exports of general manufactures of aluminium are restricted will be increased from £180 per ton to £220 per ton. These arrangements, first introduced in July, 1950, restrict exports of aluminium goods of a low "conversion value," and the present increase takes account of higher aluminium prices. This change has been effected by the cancellation of the existing open general licence and the issue of a new one for goods over the value of £220 per ton.

QUENCHING OF STEEL.—"Quenching" is the title of a brochure issued by Edgar Vaughan and Co., Ltd., which contains notes on the quenching of steel. The mechanism of heat treatment is explained, followed by a section on quenching media in which the stages of quenching are discussed and the methods of water and of oil quenching are generally reviewed. Quenching practice is touched upon and quenching oils form the subject next under discussion, and this is followed by some notes upon interrupted or isothermal quenching, and the quenching of high-speed steel.

A FILTER MATERIAL.—The B.S.A. Group Research Centre, Sheffield, has issued a brochure entitled "Porous Stainless Steel." The group has evolved a method of producing a low carbon stainless steel powder for the manufacture of a filtering medium, and the brochure has notes upon the manufacture procedure, the possible fields of application and available grades. A table indicates the dependence of flow rates upon permeability coefficients and there are comments upon flow characteristics, strength of compacts and filter design requirements, including a worked example.

GAS TURBINE TECHNOLOGY.—Apart from its usual three-week courses, the School of Gas Turbine Technology at Farnborough is holding three special short courses this summer. Each of these courses will take one gas turbine component and devote a week to dealing with it in detail, the courses being primarily intended for design staff. One course deals with the theory and design of compressors for the period June 30th to July 4th, which is followed the next week with a course on combustion and the design of heat exchangers from July 7th to 11th, and the last course considers the theory and design of turbines from July 14th to 18th.

MATERIALS HANDLING CONVENTION.—On Friday of last week, Rubery, Owen and Co., Ltd., held a Materials Handling Convention at Whitegate, Wrexham. In the morning there was a comprehensive demonstration tour during which typical applications of material handling and transport were shown and products of the Owen organisation were on view in a static exhibition. During the afternoon the following papers were read: "Fork Trucks," by Mr. C. W. Sharp; "Pallets," by Mr. E. Coupland, M.Sc.; "Materials Handling in a Motor-car Factory," by Mr. H. P. Mott, and "Materials Handling in a Warehouse Establishment," by Mr. L. Rumley.

THE INSTITUTE OF METALS.—The Institute of Metals announces that the Council has awarded the 1952 Students' Essay Prize to Mr. J. C. Wright for his essay on "The Metallographic Investigation of Failed High-Temperature Components." For the 1953 competition the Council will present two prizes of twenty guineas each. The competition is open to student members of the Institute and those eligible for student membership within the age limits of seventeen to twenty-five years. Competitors can choose their own subject but extraction and ferrous metallurgy are excluded and the essays should be between 2500 and 3500 words, and submitted in typewritten form. Each entry should reach the Secretary of the Institute, 4, Grosvenor Gardens, London, S.W.1, not later than January 1st, 1953.

TECHNOLOGICAL EDUCATION.—The Regional Advisory Council for Higher Technological Education, London and the Home Counties, 9, Tavistock House, South Tavistock Square, W.C.1, announces that its fourth annual meeting will be held on Thursday, July 10th, at Hastings. Tickets (inclusive), 13s. In the morning visits by coach are arranged to points of interest. At lunch the Deputy Mayor of Hastings will give a speech of welcome and in the afternoon there will be a meeting in the Council Chamber, the Chairman of the Council presiding. The theme of the meeting will be "Industry and Technical Education on the Continent of Europe" and Dr. E. M. Bircher, of the Swiss Legation in London, will talk on engineering industry in Switzerland and its attitude to technical education and research. Professor S. J. Davies, D.Sc., of King's College, University of London, will speak on: "The Education of Engineers in some European Countries," followed by an open discussion. At the invitation of the Right Worshipful the Mayor of Hastings, tea will be taken in the Town Hall.

INDUSTRIAL CO-PARTNERSHIP ASSOCIATION.—The twenty-second Summer Conference of the Industrial Co-Partnership Association, of 36, Victoria Street, London, S.W.1, will be held at Girton College, Cambridge, from July 18th to 21st. At the opening session on Friday evening the chair will be taken by Mr. A. F. Holt, M.P., and Mr. D. Heathcote Amory, M.P., the Minister of Pensions and Chairman of the Association, will speak upon "Leadership in Industry." On Saturday morning, under the chairmanship of Mr. A. Ryrie, M.A., LL.B., Mr. F. J. Holroyde, Major S. R. More-Molyneux and Mr. W. Wallace, will speak about "Sharing Profits and Sharing Problems." A panel consisting of Messrs. G. Mathieson, A. Ryrie, and G. P. Waddington will discuss points of practice of co-partnership and profit-sharing in the afternoon and at the evening session "Sharing the Information" will be the subject of Colonel J. K. L. Wenham, Mr. S. N. Whibley being in the chair. Mr. J. D. Burrows will take the chair at the fifth session on Sunday afternoon, when Mr. J. R. Cuthbertson will talk on "What Profits Has Industry to Share." At the final session the chairman will be Mr. W. Upton, and Mr. C. L. G. Fairfield, M.A., will take as his subject "Some Problems of the Electronics Industry." The conference, the fee for which is five guineas, is open to those interested whether members of the Association or not.

THE NEW BUILDING LICENSING LIMIT.—The Minister of Works said in the House of Commons on Tuesday last that he is making an Order continuing for the twelve months from July 1st the present limit of £500 for industrial and agricultural buildings but increasing the limit for other buildings to £200. In issuing licences for repair and maintenance above the free limits careful regard will be had to the load of work in the area concerned. In connection with this announcement, the Ministry of Works explains that the term "industrial buildings" means, generally speaking, factories and workshops. It does not include commercial premises, shops, banks, offices, warehouses, and the like.

Personal and Business

MR. T. P. RENTON has been appointed divisional manager for Dunlopillo in Scotland.

MR. W. YOUNG has joined Foundry Services, Ltd., as technical representative in the Scottish area.

FOSTER TRANSFORMERS AND SWITCHGEAR, Ltd., states that it has changed its name and will in future be known as Foster Transformers, Ltd.

SIR LUKE FAWCETT, O.B.E., has been appointed chairman of the Southern Regional Board for Industry in succession to Mr. C. C. Griffith, M.C.

SMALL AND PARKES, Ltd., has opened a new Don brake and clutch lining depot at 50, Old Market Street, Bristol (telephone, Bristol 27214).

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., announces that Mr. A. E. H. Boaz has been appointed manager of the Falmouth depot.

MR. FRANK ELLIS, London agent of Rêde Ferroviária do Nordeste, states that his postal address has been changed to 111, Moorgate, London, E.C.2 (telephone, Monarch 1722–3).

MR. OLIVER W. J. FARMER has been appointed manager of Mazda lamp and lighting advertising for the British Thomson-Houston Company, Ltd., in succession to Mr. H. E. Goody, who is retiring at the end of July.

PHILCO TECHREP CONSULTANTS states that activities now conducted from 93, Regent Street, London, W.1, will be carried out from Philco (Overseas), Ltd., Lion House, Richmond, Surrey (telephone, Richmond 5661); (London telephone, Grosvenor 6531).

NATIONAL PRODUCTION AUTHORITY, Department of Commerce, announces the appointment of Mr. Richards W. Cotton, of the Philco Corporation, Philadelphia, as Director of the Electronics Division, and Chairman of the Electronics Production Board, Defence Production Administration.

THE UNITED STEEL COMPANIES, Ltd., announces that Mr. H. E. Wright is retiring from the position of general manager of the Steel, Peech and Tozer branch at Rotherham. He will be succeeded by Mr. Andrew Jollie. Mr. G. E. D. Halahan will succeed Mr. Jollie as general works manager.

MR. R. H. JAMES states that he has set up in private practice in partnership with Mr. T. E. Crowley as a production consultant in building and civil engineering work, under the title R. H. James and Partners, at 7, Hobart Place, Westminster, London, S.W.1 (telephone, Sloane 9860).

THE BOARD OF TRADE announces that the President has appointed Lady Sempill, Miss Mary Grieve, Mr. George Breeze, Mr. Lynton H. Lamb and Mr. Walter Lines to be members of the Council of Industrial Design. He has also reappointed Mr. Geoffrey Dunn, Mr. Leslie Gamage, Mr. John Gloag, Mr. G. W. Lacey, Sir William Palmer, Major F. J. Stratton and Dr. W. J. Worboys to be members of the Council on the termination of their existing appointment. The President has also appointed Mr. W. D. Ritchie to be a member of the Scottish Committee of the Council of Industrial Design. Lady Sempill, Mr. J. Douglas Hood, Mr. J. McMurtrie Kay and Mr. Andrew Nairn have been reappointed to the Scottish Committee on the termination of their existing appointment.

British Patent Specifications

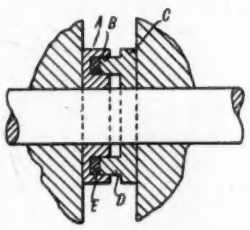
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

TOOLS AND WORKSHOP APPLIANCES

673,380. October 31, 1949.—Self-Aligning Washers, Cyril Graham Bruce and Molins Machine Co., Ltd., 2, Evelyn Street, Deptford, London, S.E.8.

An object of the invention is to provide a self-aligning washer for use with mandrels and milling machine arbors. The construction is illustrated in the drawing. A metal ring *A* has a groove *B* in it and a co-operating ring *C* has a circular ring *D* formed on one face, which enters the groove.

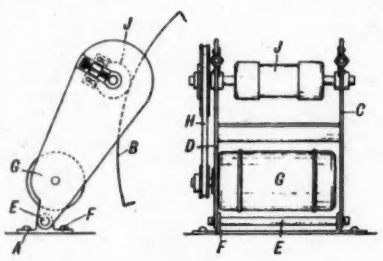


No. 673,380

Between the base of the groove and the face of the ring is a rubber washer *E*. The parts *B* and *D* fit with a slight circumferential clearance so that the rings *A* and *C* may rock slightly with respect to one another. If rubber, either natural or synthetic, is used, it may be bonded to the metal rings and the device made as a single unit. Any suitable material may be used for the elastic ring, many plastics being suitable.—*June* 4, 1952.

673,785. October 18, 1950.—Electric Driving Arrangements for Common Grindstones, Arne Henriksen, Tordenskjolds plass 4, Oslo, Norway.

The invention relates to a driving engagement for common grindstones without substantial modification of the supporting means. Referring to the drawings, *A* indicates a support of a grindstone *B* of usual construction. The driving arrangement comprises a frame having two side members *C* and *D*, which are secured to a pivot shaft *E*



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carried by a bracket *F* secured to the support. Between the side members is an electric driving motor *G* connected by a belt *H* to a drum *J* with suitable gearing ratio. The drum is supported in journals carried by the side members. When this driving arrangement is placed upon the support, as illustrated, in the left-hand view, the driving drum rests against the periphery of the grindstone and by choosing the transfer ratio between the motor and the drum correctly the grindstone will be rotated at desired speed by friction.—*June* 11, 1952.

METALLURGY

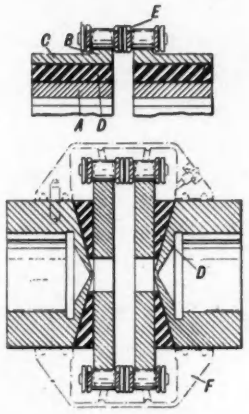
673,901. August 12, 1949.—Brazing Stainless Steel, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: Eric James Whitehead.*)

This invention relates to brazing and the like operations with stainless steels. According to the invention, the method of brazing comprises the steps of supporting the parts to be joined in a jig, or in any other convenient manner, applying the solid brazing metal to the joint, and then lowering the parts into a bath of a molten flux made up of boric acid and cryolite, and maintained at a temperature high enough to effect brazing. A sound joint is formed as soon as the parts acquire the bath temperature. It is preferred to use copper as the jointing material, but silver solder wire may be employed. With this jointing material, however, it is usually necessary to locate the wire by trapping. With the method described it is preferred that the clearance between the parts to be joined should not be greater than 0·00075in, and the parts should be lowered into the molten flux bath in such a way as to avoid air being trapped. One suitable form of flux bath especially suitable for brazing austenitic stainless steels comprises 95 per cent by weight boric acid and 5 per cent cryolite and the bath is best used at a temperature of 1100 deg. to 1120 deg. Cent. On removal from the bath the parts are protected from oxidation during cooling down by the coating formed by the solidification of the flux. By employing the brazing method described it is claimed that satisfactory joints have been obtained which do not fail due to vibration fatigue when employed on parts of engines.—*June* 11, 1952.

POWER TRANSMISSION

673,552. December 23, 1949.—Flexible Couplings, The Renold and Coventry Chain Company, Ltd., Renold Works, Didsbury, Manchester, and Onissim Burawoy, of the company's address.

In the upper drawing the hub *A* of each sprocket of a chain coupling is a plain cylinder with a key way for securing to a shaft. The rim *B* has an



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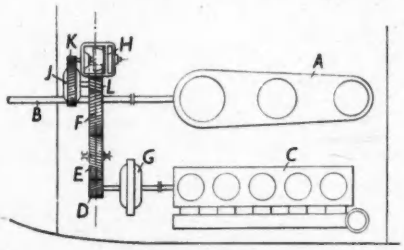
axial flange *C* of equal length to the hub and a rubber ring *D* is bonded to cylindrical surfaces on the hub and rim. The coupling is completed by a double roller chain *E*. In the specification various alternative designs are shown. In the coupling shown in the lower drawing the rubber ring *D* is of greater radial extent to give a greater area of bond.—*June* 11, 1952.

MARINE ENGINEERING

673,789. October 26, 1950.—Marine Power Plant, Aktien-Gesellschaft "Weser," 18, Werftstrasse, Bremen, 13, Germany.

The invention refers to a power plant consisting of a steam engine, an exhaust steam turbine and an internal combustion engine for driving a ship's propeller shaft. As shown in the drawing, the shaft of the steam engine *A* is connected with the propeller shaft *B* either directly or through a mechanical clutch. The provision of a mechanical clutch between the shaft of the piston steam engine and the propeller shaft allows the propulsion of the



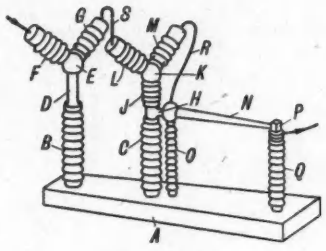
No. 673,789

ship to be changed over to the internal combustion engine alone. The internal combustion engine *C*, alongside the piston steam engine *A*, drives through the pinion *D* and the intermediate wheel *E*, the large gearwheel *F* on the propeller shaft *B*. Between the internal combustion engine and the pinion the hydraulic turbo-coupling *G* is provided. The exhaust steam turbine *H* drives the hydraulic turbo-coupling *J*, constructed as a gearwheel, through the pinion *K*, and the pinion *L* also drives the gear wheel *F* on the propeller shaft. The exhaust steam turbine runner is in the same plane as the gear. The gear parts and the exhaust steam turbine are so mounted in the casing that the two turbo-couplings lie, respectively, on the two sides of, and the turbine in, the gear plane.—*June* 11, 1952.

ELECTRICAL ENGINEERING

673,598. August 15, 1950.—High Tension Circuit Breakers, Allmanna Svenska Elektriska Aktiebolaget, of Vasteras, Sweden.

The invention concerns high tension circuit breakers, and has the advantage that a special carrying insulator is not necessary for the isolator connected with the circuit breaker. Referring to the drawing, *A* is the base frame of the circuit breaker, on which two insulating pillars *B* and *C* are mounted. On the top of the insulator *B* a metal pipe *D* is mounted which carries a joining piece *E*, which, in its turn, carries the two breaking elements *F* and *G*. On the top of the insulator *C* a gear housing *H* is mounted which supports an insulating cylinder *J*. This supports a joining



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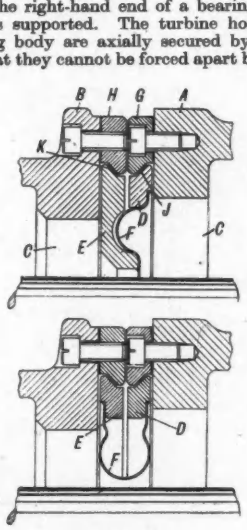
piece *K* carrying the breaking elements *L* and *M*. The isolator arm *N* is pivoted in the gear housing *H* and is operated by an insulating operating shaft *O*. The stationary contact *P* of the isolator is mounted on the top of the free insulator *Q*. *R* is a connection from the isolator arm to the breaking element *M* and the breaking element *L* is connected with the breaking element *G* by the connection *S*. The connection of the circuit breaker to the network takes place on one hand at the free end of the breaking element *F* and on the other hand at the isolator stationary contact *P*.—*June* 11, 1952.

SEALING DEVICES

674,280. May 3, 1950.—Sealing a Space Under Super-Atmospheric Pressure, Aktiengesellschaft Für Technische Studien, of Hardstrasse 319, Zurich, Switzerland.

The invention relates to a device for sealing a space under pressure which is situated between two coaxially arranged hollow machine parts exposed to unequal temperatures. The upper drawing shows the high-pressure end *A* of a turbine housing through which the turbine shaft emerges, and *B* is the right-hand end of a bearing body in which it is supported. The turbine housing and the bearing body are axially secured by the base plate so that they cannot be forced apart by internal



No. 674,280

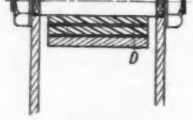
pressure. *C* is a space in which a super-atmospheric pressure is to be sealed. In the space two rings *D* and *E* are arranged coaxially to the turbine shaft between the parts *A* and *B* and are connected in gastight fashion by a flexible and elastic diaphragm *F*. The two rings *D* and *E* are bevelled in opposite directions on their outer circumference. *G* and *H* are two rings, the halves of which are connected together in the separating gap by screws. The two bevelled surfaces define a gap

filled with elastic packings *J* and *K*. The pressure in the space *C* forces the bevelled peripheral surfaces of the rings tightly against the packings, so the escape of medium from the space into the atmosphere is prevented. The modification shown in the lower view differs from that already described only in the different form of the one-part rings *D* and *E* located in the super-atmospheric pressure space and of the elastic diaphragm *F* of "U"-section by which these rings are connected.—*June* 18, 1952.

BEARINGS AND SUPPORTS

674,239. May 11, 1949.—RESILIENT BEARINGS, Tom Edgerton Clarke Hirst, 163, Woodside Avenue, Coventry, Warwickshire.

In the accompanying drawing *A* is the housing formed with a cylindrical bore and the space between the inside of the housing and the outside surface of a suitably shaped intermediate tube *B*, and the space between the inside surface of the intermediate tube and outside surface of the pin *C* is filled with rubber *D* in a free state, which is free from stress when there is no load applied between the parts. When the load is applied the rubber is subjected to a compressive stress and



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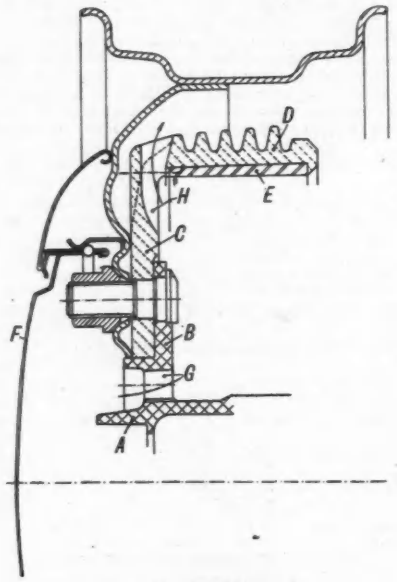
takes a sufficient hold on mating surfaces to locate the parts *A* and *C* relative to one another. The rubber is not bonded, vulcanised or connected by adhesive to the mating surfaces. Relative oscillating motion between the pin and the housing is taken by the stretching or deformation of the rubber. Alternative forms of intermediate tube are shown in the specification.—*June* 18, 1952.

ROAD TRANSPORT

673,569. June 28, 1950.—COOLING DEVICE FOR MOTOR VEHICLE BRAKES, Fiat Società per Azione, of 300, Corso IV Novembre, Turin, Italy.

This invention concerns a device for establishing a forced draught circuit within the drums of motor vehicle brakes. In the accompanying drawing *A* is the hub carrying the radial flange *B*, attached to the disc *C* of light metal alloy, and fixed to the ribbed drum *D* of the brake, which is provided with



No. 673,569

an inner lining *E*. The flange carries bolts for the assembly of the wheel disc. *F* is the cover which is fitted to the outside of the wheel disc. The flange *B* is formed at its lower end with a circular row of holes *G*, and the disc *C* has a peripheral set of conduits *H*. The profile of the conduits is such that on rotation they suck in air, in the direction of the arrows through the holes, and deliver it to the outside along the periphery of the brake drum. In this way the cooling air cools the shoes and drum without the danger of slipping.—*June* 11, 1952.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Industrial Administration

Thurs., July 10th.—LONDON CENTRE GRADUATE SECTION: Management House, 8, Hill Street, W.1, "The Presentation of Data as an Aid to Efficiency," B. P. Dudding, 7 p.m.

Institution of Civil Engineers

Fri., July 11th.—Summer meeting in Coventry and Stratford-upon-Avon. Coaches leave the James Watt Memorial Institute, Great Charles Street, Birmingham, 1 p.m.

Institution of Mining Engineers

To-day, July 4th.—Summer Meeting at Keele, near Stoke-on-Trent.

Institution of Sanitary Engineers

To-day, July 4th.—Caxton Hall, Westminster, London, S.W.1, annual general meeting, 5.15 p.m., "Crawley New Town Engineering Works," A. J. W. McIntosh, 6 p.m.

Sat., July 5th.—Whole-day visit to Crawley New Town residential neighbourhoods and factory area, sewage treatment works, Weir Wood impounding reservoir with dam, under construction, and small prestressed concrete reservoir.

Manchester Association of Engineers

Sat., July 19th.—Visit to Messrs. Cammell Laird's Shipyards, Birkenhead. 2 p.m.

Regional Advisory Council for Higher Technological Education, London and the Home Counties

Thurs., July 10th.—Fourth Annual Meeting at Hastings.

Launches and Trial Trips

ENTON, cargo liner; built by Alexander Stephen and Sons, Ltd., for Birt, Potter and Hughes, Ltd.; length between perpendiculars 432ft, breadth 58ft 9in, depth 39ft 6in, load draught 27ft 2in, deadweight 9900 tons, 6440 gross tons, sea speed 14 knots; five cargo holds, 10-ton derricks and one 30-ton derrick; Barclay Curle-Doxford oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m. Trial, May 1952.

OBUASI, cargo liner; built by Harland and Wolff, Ltd., for Elder Dempster Lines, Ltd.; length between perpendiculars 415ft, breadth moulded 60ft, depth moulded to shelter deck 34ft, 5600 gross tons; Harland and Wolff-B. and W. two-stroke, single-acting, opposed-piston, eccentric, diesel engine, five cylinders, 620mm diameter by 1870mm combined stroke, 115 r.p.m., four 125kW diesel generators. Launch, June 24th.

CORBRAE, motor collier; built by the Burntisland Shipbuilding Company, Ltd., for William Cory and Son, Ltd.; length between perpendiculars 258ft, breadth 39ft 3in, depth moulded 18ft 11in, deadweight 2700 tons, draught 17ft 5in; British Polar diesel engine, eight cylinders, 340mm diameter by 570mm stroke, 1050 b.h.p. Launch, June 25th.

VERMICULITE.—A monograph entitled "Vermiculite," by E. R. Varley, has recently been published by the Mineral Resources Division of Colonial Geological Surveys. Vermiculite is a collective name, both in science and in the building trade, for a group of minerals which, when suitably treated, are becoming increasingly important in industry. These minerals are unspectacular in appearance in the field, resembling inferior grades of mica, but all have the property of expanding or exfoliating when heated. The expanded material, extremely light in weight and possessing outstanding insulating properties, is employed in the manufacture of light-weight concrete, plaster and a large variety of thermal and acoustic insulating products, in addition to a number of miscellaneous materials. The volume has a foreword by Dr. F. Dixey, Director of Colonial Geological Surveys, who draws attention to the importance of constructional materials in the Colonial Territories, and the possibilities of local usage and even export of good-quality material if such can be found. The salient facts concerning vermiculite are presented, including its mode of occurrence, properties, mining and preparation, world production and consumption, prices, uses, and descriptions of producing regions, and as such information has hitherto not been easily available in this country. The monograph may be obtained from H.M. Stationery Office, price 7s. 6d.

Technical Reports

A Pulse Generator Producing 0·01μsec Pulses (Ref. M/T113). By S. F. Pearce and D. C. G. Smith. The British Electrical and Allied Industries Research Association. Price 7s. 6d., postage 3d.—This report describes the construction and performance of a pulse generator based on a design developed by the U.S. Army Signal Corps Laboratories. The pulse, produced by a gas tetrode, has a duration of approximately 0·01μsec and may be repeated at rates between 0·3 and 10,000 pulses per second. It provides a valuable tool for the testing and checking of interference-measuring sets, particularly of the C.I.S.P.R. type, in the frequency range 0·15Mc/s to 30Mc/s. The performance of the circuit is analysed in some detail and the features limiting the frequency range covered are clarified.

The Incidence and Avoidance of High Resistance Joints in Steel Conduit Runs in Service (Ref. V/T109). By L. Gosland, B.Sc., M.I.E.E., and E. R. Hutchings, B.Sc. (Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association. Price 12s., postage 3d.—A survey of results obtained on practical installations is made in this report, and measurements of the resistance of laboratory runs over periods of up to six years, both indoors and outside, are analysed. The effect of the application of various protective materials to joints is also studied. Recommendations are made for improving the performance of conduit joints and for specifying the permissible resistance and its method of measurement.

An Investigation to Develop Methods of Test for Impregnating Varnish (Ref. A/T124). By H. R. Heap, B.Sc. The British Electrical and Allied Industries Research Association. Price 21s., postage 4d.—This report gives an account of experiments on the suitability of a test specimen consisting of a standard test coil which can be impregnated by a standard procedure. The advantages and disadvantages of the proposed test method are carefully weighed.

Calculated Curves of Inductive Energy at the Start of Arcing in Fuses (Ref. G/T246). By H. W. Baxter, B.Sc. (Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association. Price 12s., postage 4d.—This is a further report in the series dealing with fundamental principles of fuse operation, the preceding report being Ref. G/T245. It contains an account of the method of calculation used in preparing curves to show in given cases the prospective current at which the inductive energy in the circuit is a maximum.

Strength Tests on Driven Large Diameter Aluminium Rivets. By J. C. Bailey, B.Sc., and A. W. Brace. Research Report No. 13, The Aluminium Development Association. Price 7s. 6d.—Previous work is briefly reviewed, the results obtained by various investigators are recorded and the report goes on to discuss the tests undertaken on single riveted specimens to determine the shear and tensile strengths of driven aluminium alloy rivets larger than ½in diameter, in a range of alloys some of which are not generally used for riveting. In addition the strength and quality of joints made with rivets having various points, hole sizes and driving methods. The joints have been examined and assessed in the usual way and also by a new radiographic system. The preparation of panels for single and double shear tests is described and illustrated and also test procedure. In the section dealing with test results tabular statements give the effect of hole clearance on shear stress, shear load and tensile strength, and hammer and squeeze driven rivets are compared. Other tables give driving times, compare the shear stress obtained with various hammer-driven points, and the effects of hot and cold driving on tensile strength and shear stress. Appendices in a series of tables record the individual shear and tensile test results and the results of the examination of the joints, including visual, radiographic and macro-examination are described and illustrated, together with tables of hardness values. The main conclusions drawn from a study of the detailed results indicate that no differences were observed in the ultimate stress in single and double shear except with countersunk points; hole clearances between $^{1}/_{64}$in and $^{3}/_{64}$in did not affect tensile or shear stress, but that maximum load increased with hole clearance; hot driven rivets in non-heat-treatable aluminium magnesium alloys are weaker than cold-driven; heat-treatable rivets driven in the freshly quenched condition were lower in strength than naturally aged rivets; squeeze driving gave the more consistent shear stress values and slightly higher values in certain non-heat-treatable alloys; and that the conventional point shape did not influence strength but rivets with the modified pan point developed full strength.